POWER PLANT ENGINEERING

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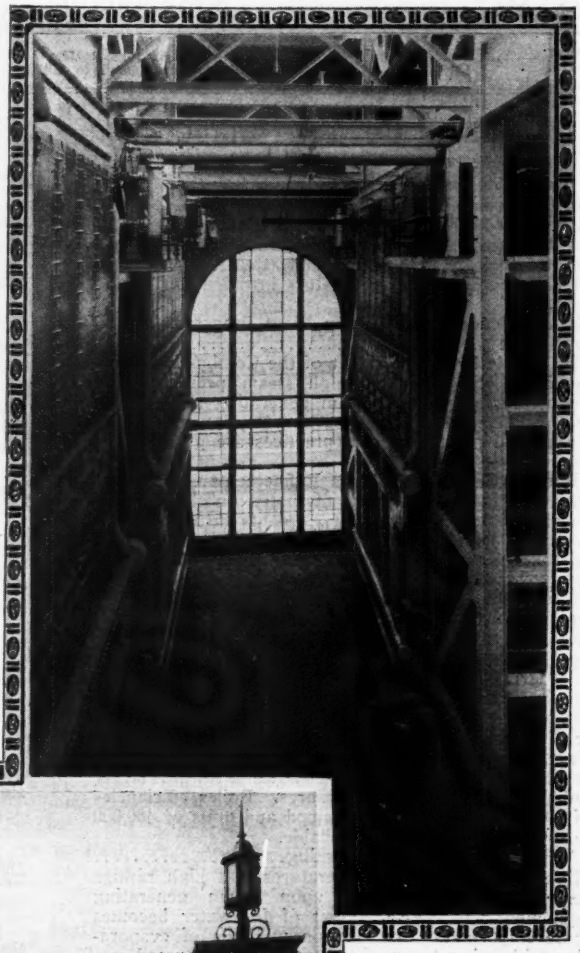
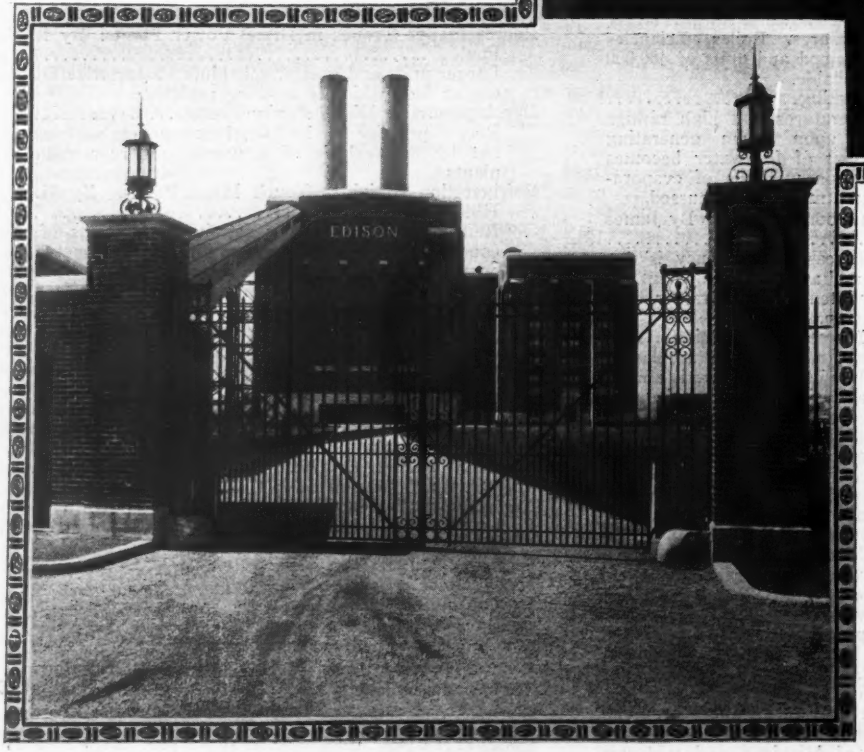
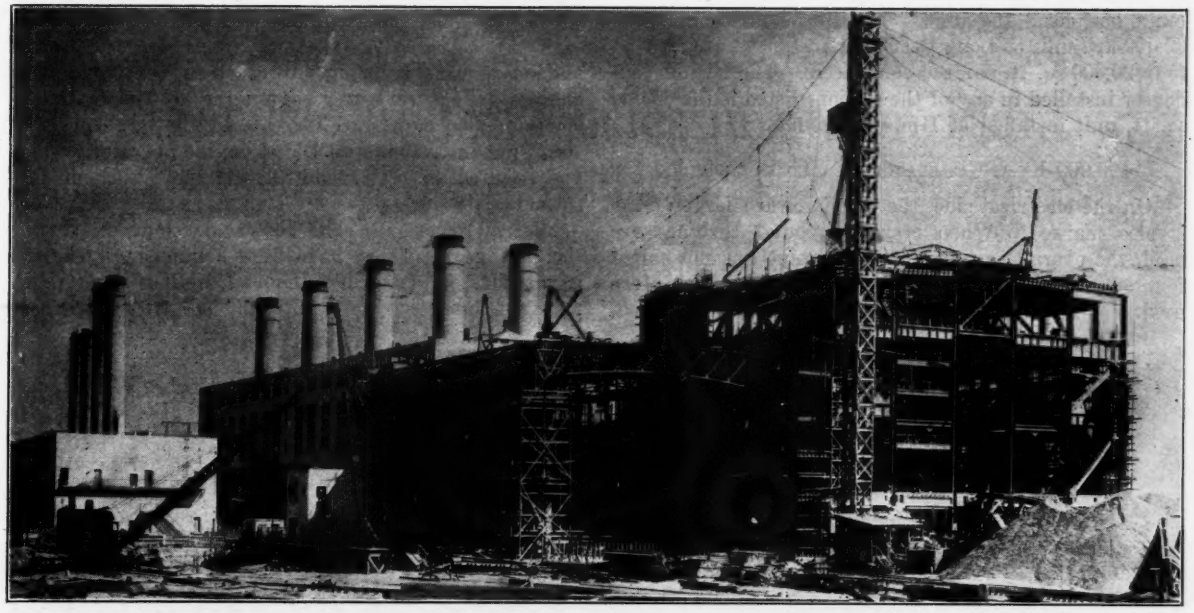
FROM EDGAR TO LONG BEACH—

OR AS THE poets would say,—from the storm swept coast of New England to the sun drenched sands of California, these two photographs typify progress in American power plant practice. The picture at the the right is a view of the interior of the boiler room at Long Beach Station in California while below is shown an unusual view of the Charles Leavitt Edgar Station at Boston, Massachusetts. Situated at opposite sides of the continent, these two stations nevertheless embody the most advanced ideas in design and operation. With the first 10,000-kw., 1300-lb. pressure turbine and boiler installation, Edgar is one of the pioneer high-pressure stations in America. Long Beach, with the largest single cylinder electric generator in the world, complete automatic combustion control and centralized control of stage heaters is a monument to the accomplishments of the engineering profession. Compare the boiler room at Long Beach shown here with the average boiler room of 20 or even 10 yr. ago. It is a long stretch from the dismal smoke-begrimed firing aisles of those days to the classic design of Long Beach, yet, in point of time, it was only yesterday. Progress has been extremely rapid. Whether it will be as rapid in the future is impossible to foretell, perhaps not, but that will not deter the engineer from continuing the task in which he has already so brilliantly succeeded.







Station Extensions Mark Progress in 1928

IMPROVEMENTS IN USE OF PULVERIZED FUEL, LARGER TURBINES AND GENERATORS, NEW METHODS OF COOLING, A FEW OF THE DEVELOPMENTS OF THE YEAR

ONE OF THE significant features brought out by a study of progress in the power plant field during the year 1928, is the fact that very few new stations were built. Practically all of the new work consisted in the extension of stations built several years ago. This, of course, was to be expected. During the past five years, plants were built all over the country having ultimate capacities far in excess of the initial installation; as a consequence it is to be expected that development during the next few years will consist largely in bringing such plants to completion.

With only five exceptions, the data on all central stations contained in this issue applies to additions or extensions. The five exceptions are: Vienna Station, Gould St., Long Beach No. 3, Trinidad and Lake Pauline. Long Beach No. 3, although really an addition to Long Beach steam plants Nos. 1 and 2, is considered as a new plant because it is housed in a building entirely separate from the first two units.

The first 17 stations, listed in the order in which they appear in the tabulations, are central station plants while the last 6 are industrial plants. With the exception of the U. S. Rubber Co. Plant, the industrial plants are all new. No particular reason can be ascribed to their selection other than that they are representative and are indicative of modern power plant practice. The geographical locations of the plants, at first thought, might seem to be somewhat unbalanced but when the distribution is considered relative to the distribution of industry, it will be found quite equable.

This year's analysis shows a continuation of the trend toward the use of the unit system in pulverized coal practice, although the central system is used in a number of plants. In this analysis, out of 11 stations using pulverized fuel, 8 use the unit system and 3 the central system.

An interesting fact shown is the increased use of the turbulent type burner. With the exception of two plants (Gould St. and Trinidad), all use some form of turbulent burner or an arrangement of burners to produce turbulence in the furnace.

Water-cooled walls predominate. The hearth screen is used in some cases; in others the bottom of the furnace is shaped like a hopper with water-cooling surface extending down the sides. Water-cooled walls are used more extensively with stokers this year than heretofore.

Stokers, on the whole, are larger and more attention is being given the question of air control and distribution. One new type consists of underfeed sections feeding onto short rear sections that are given a wave-like motion to break up the coke.

Air preheaters are, in most cases, of the plate or tubular type, although other types are in use. A split-section air heater is a new development. Air temperatures as high as 500 deg. are used under some of the stokers.

Furnace sizes for stokers range from ratios of 0.22 cu. ft. of furnace volume to square feet of heating surface to 0.66. For pulverized coal, these ratios range from 0.67 to 1.9, the average being around 0.9.

Turbine room practice this year has followed much along lines started several years ago with a steady increase in the size of units. Among the larger units installed are the two 160,000-kw. units at Hell Gate, the 165,000 kw. unit at Philo, the 110,000-kw. machine at Hudson Avenue and the 104,000-kw. unit at Crawford Avenue. The highest pressure turbine placed in service is the 10,000-kw., 1290-lb. pressure unit at Edgar Station.

With the development of these extremely large turbines has come the use of multiple condensers. The 90,000-kw. unit at Long Beach for instance, is served by four 20,000-sq. ft. surface condensers. The largest condenser installed in any of the stations listed is the 85,000 sq. ft. unit installed at Hudson Avenue.

100,000 Kv.a. Generator Placed in Service

On the electrical side, the trend toward larger units is also marked. When cross compound turbines are used, the overall capacity of the turbine has not called for generators of greater capacity than those heretofore used, but where tandem compound units are installed, with single generators, the capacity of the generators has been increased considerably. The largest single generator placed in service this year is the 100,000-kv.a machine at Long Beach Station No. 3.

Use of Hydrogen for Cooling

An interesting development in the electrical field is the hydrogen cooled synchronous condenser installed at Pawtucket, R. I. This method of cooling was suggested last year for use with electric generators, but so far, no application of this method has been made to generators.

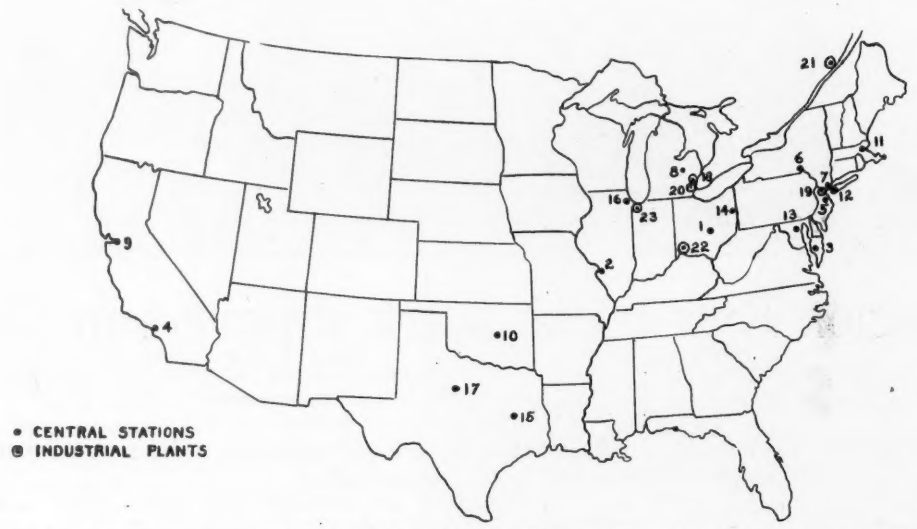
Among the new developments in the field of electrical transmission, perhaps the one of greatest interest is the use of series capacitors for compensating the inductive reactance of the transmission line. The first installation of this equipment has been made on the lines of the New York Power and Light Corporation at Ballston, N. Y.

In the Diesel engine field, larger units and higher speeds are being used. There is a greater application of water softening processes to water used for cooling and more care is being exercised in construction of engines to ensure better scavenging of the cylinders. There is also a marked increase in the application of recording instruments to Diesel engine operators, which has resulted in better control and more efficient performance.

Refrigeration also has shown development during the past year. There have been a number of changes in methods of installing equipment and in the development of labor saving equipment, all of which have contributed to increase the overall efficiency of the plant. A number of large cold storage warehouses have been installed during the year, showing the tremendous growth in the use of refrigeration as a preservative. As a general rule, these plants employ two brine temperatures, a low temperature for sharp freezing and a higher one for general storage work.

In this introductory article, we have been able only to direct attention to some of the outstanding developments in certain branches of the power plant field. There are many other developments of interest about which no mention has been made but which are described in other articles in this issue.

Taken as a whole, the year 1928 has been marked by a general increase in the efficiency and reliability of all power plant equipment. If startling developments have been few, it is satisfying to observe on all sides a greater appreciation of the fact that closer attention to many relatively minor things results in a general improvement of the plant as a whole.

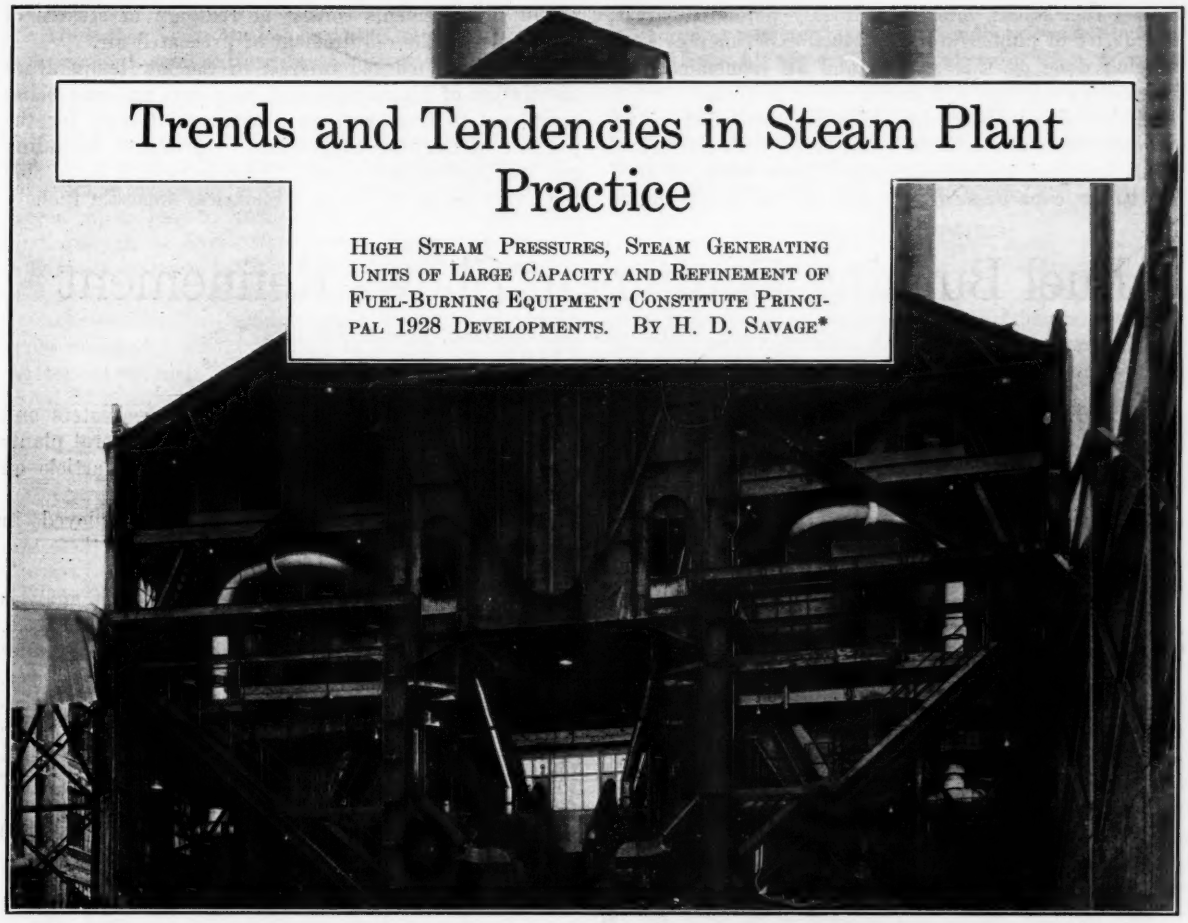


MAP OF UNITED STATES SHOWING LOCATIONS OF THE STATIONS COVERED IN THIS ISSUE

1—Philo Station, Philo, Ohio
2—Cahokia Station, St. St. Louis, Mo.
3—Vienna Station, Vienna, Md.
4—Long Beach No. 3, Long Beach, Cal.
5—Kearny Station, Kearny, N. J.
6—Binghamton Station, Binghamton, N. Y.
7—Hell Gate Station, New York, N. Y.
8—Saginaw River Station, Zilwaukee, Mich.
9—Station C. P. G. & E. Co., Oakland, Cal.
10—Horseshoe Lake Station, Harrah, Okla.
11—Edgar Station, Weymouth, Mass.
12—Hudson Ave. Station, Brooklyn, N. Y.
13—Gould St. Station, Baltimore, Md.
14—Toronto Station, Toronto, Ohio
15—Trinidad Station, Trinidad, Texas
16—Crawford Ave. Station, Chicago, Ill.
17—Lake Pauline Station, Quanah, Texas
18—U. S. Rubber Co. Plant, Detroit, Mich.
19—Acheson Harden Co., Passaic, N. J.
20—Piston Ring Co., Muskegon, Mich.
21—Anglo Canadian Pulp and Paper Co., Limoilou, Quebec, Can.
22—Sorg Paper Plant, Middleton, Ohio
23—Stanolind Station, Whiting, Ind.

Trends and Tendencies in Steam Plant Practice

HIGH STEAM PRESSURES, STEAM GENERATING UNITS OF LARGE CAPACITY AND REFINEMENT OF FUEL-BURNING EQUIPMENT CONSTITUTE PRINCIPAL 1928 DEVELOPMENTS. BY H. D. SAVAGE*



DURING THE YEAR that is nearly past, there have been definite indications of increase in steam pressures, both in central stations and industrial plants. Fourteen-hundred-pound-pressure units are going into service in the central station field and 1800-lb.-pressure units are being built for a manufacturing plant in Ohio.

Undoubtedly the industrial field offers the greatest opportunity for economies secured from increased steam pressures, as not only the gain from the employment of relatively high pressures is secured but, where process steam is necessary and a fair demand for power exists, the cost of power is relatively small, through the use of back-pressure or stage-bleeding turbines. In this connection, where large demands for process steam exist in certain industries, the sale of power to the public utility companies offers possibilities.

It is interesting to note that the units referred to are by no means small units. The 1400-lb. units are designed for a steam capacity of 200,000 lb. per hr. and the 1800-lb. units for 150,000 lb. of steam per hour.

Reliability shown by the modern boiler unit, with its water-cooled furnace, which is undoubtedly one of the major developments of steam generating equipment, has made it possible to meet the demand for high sustained ratings of boiler units of relatively large capacity. Units producing 500,000 to 700,000 lb. of steam per hour are in operation and designs have been made for units to produce 1,000,000 lb. per hour. Superheating and reheating temperatures seem to reach their limit between 725-750 deg. F. in the United States, even though Continental plants have been built and projected for 850-900 deg. F.

Manufacture of such units as mentioned, which are continually lowering the steam generating cost of our central stations and industrial plants, involves a necessity for coördinated design. So many new problems of water circulation, steam delivery free of moisture, furnace design and the like are met, that the responsibility for the overall results must be placed in one manufacturer's hands.

Trend of developments in fuel burning apparatus has been mostly directed to detail improvements in existing methods. The central station and the industrial plant in particular show an increase in the use of pulverized fuel. The storage system of pulverized fuel shows a decided trend towards simplification. Dryers are eliminated through the use of preheated air in the mill. Mill capacities have increased; units are now being built of 60,000-70,000 lb. capacity per hour. The same applies to the unit, or direct-fired, system. Turbulent firing, to increase the combustion rates per cubic foot of combustion space, is prevailing. The turbulence is obtained either through the use of a turbulent mixing type of burner, by tangential firing, or by location of burners which provide a turbulent action through flame impingement.

The question of dust and ash collection from pul-

*President, Combustion Engineering Corp., New York.

verized fuel stacks, located in thickly populated areas, is a matter of public interest. Much experimental work is being done on this subject and an economical and satisfactory solution will undoubtedly be found.

Stoker development has followed the trend of requirements, by necessity of competition with pulverized fuel. Inclined underfeed stokers have been installed for boiler capacities of 400,000 lb. in single units. Detail improvements consist of redesign of stokers to conform with the requirement of preheated air.

There is a marked interest in the low temperature distillation of bituminous coal, as plants are now being completed to treat coal on a commercial scale for the purpose of utilizing the various by-products, including gas, tar, liquors, and so on. The coke residue is suitable for power plant use or as a smokeless domestic fuel.

Fuel Burning Equipment Shows Refinement

INCREASING USE OF UNIT MILLS AND MILL DRYING, LARGER STOKERS, TURBULENT BURNERS ARE DISCUSSED IN THE LIGHT OF THE TABULATED ANALYSIS

AS POINTED OUT by Mr. Savage in the preceding article, refinement of details of fuel burning equipment, rather than enunciation of new principles, has been the outstanding characteristic of the developments of 1928 in the boiler house.

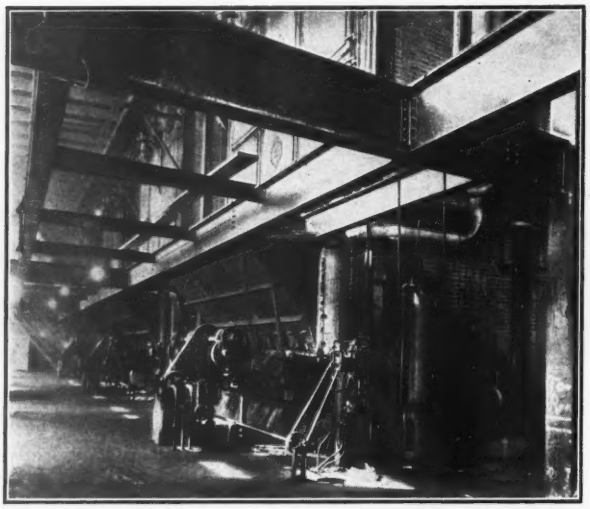


FIG. 1. UNDERFEED STOKERS AT PLANT OF ANGLO-CANADIAN PULP & PAPER CO.

Simplification of the bin or central system of preparation and increasing use of unit mills have led to more frequent employment of mill drying and less frequent use of the separate coal dryer. Use of turbulent burners or arrangements of burners to give turbulent flame in the furnace are increasing. Use of water-cooled walls, especially with stokers, is of importance, while much interest has been aroused by installations of water-cooled furnaces with flat bottoms, in which ash is allowed to remain molten and is tapped off in liquid form. Such furnaces are usually supported on springs. A cylindrical air-cooled furnace has been in operation with good results. Both hearth screens and water-cooled hopper bottoms are in use.

REFINEMENTS IN STOKER DETAILS

Stokers, on the whole, are increasing in size, although several installations of small stokers have given excellent results. More care is now given to distribution of air under the stoker, especially for admitting air at the rear of the stoker and in the clinker grinder pit to burn out combustible in the ash. Most of the large installations use clinker grinders. Air preheaters and a new type of induced draft fan used by several plants are discussed later, for convenience, in the article on furnace construction.

Automatic combustion controls are employed in many cases with great success but details of these systems are beyond the scope of this article.

Coal used in the plants treated in this analysis ranges all the way from the Kincaid coal of 10,500 B.t.u. per lb. used at Crawford, through the various grades up to the West Virginia coals of 14,000 B.t.u. or over, as used at Vienna. Horseshoe Lake burns a semi-anthracite of 12,760 B.t.u. per lb. or a petroleum coke of 14,957 B.t.u., both in pulverized form, while Trinidad pulverizes Texas lignite with average heat value of 6900 B.t.u. per lb. Oil used by three of the stations averages 18,500 B.t.u. per lb. and gas 1000 to 1200 B.t.u. per cu. ft.

TREND TOWARD UNIT MILLS AND MILL DRYING CONTINUES

As a study of the tabulations will show, a definite trend toward the unit pulverizing mill system is apparent this year. This does not mean, of course, that the central (or storage) system will be abandoned, for it has many undisputed advantages for certain applications. In such applications, however, considerable simplification of equipment is noted, especially in respect to drying of the coal.

Of the plants tabulated, three use the central system of preparation: Binghamton, Gould St. and Trinidad. Binghamton employs a coal-fired rotary dryer, taking coal averaging 6 per cent moisture and discharging it at 0.75 per cent. For its lignite, Trinidad uses a steam grid dryer to reduce the initial moisture of 33 per cent to 28 per cent.

Gould St. dries coal in the mills from an initial moisture content of 6 per cent to a final value of 1.7 per cent. This is done with preheated air, supplied by an air preheater in which steam at full boiler pressure serves to raise the air to the proper temperature.

Moisture content of the coal varies, of course, but it is interesting to note that in only one or two cases does the table show over 5 per cent of moisture in the coal entering the furnace. As has been pointed out in previous analyses, the principal object of any drying of the coal in the modern boiler house is to make it easier to transport and pulverize, although there have been cases in which combustion was a factor. Lignite can be pulverized successfully if the proper methods

are used, as typified by the Trinidad installation, while the Horseshoe Lake station has been successful in pulverizing both semi-anthracite and petroleum coke.

Capacities and Power Consumption of Mills

Pulverizing mills used either with the central system or as unit mills vary considerably in type and capacity, as is to be expected. With storage systems, mills of larger capacities are used—20 t. per hr. at Gould St., 15 t. per hr. at Trinidad—whereas in the use of unit mills, each boiler is usually served by two smaller mills or sometimes, as in the case of Hell Gate, by four mills.

Acheson-Harden Co. installation is typical of certain types of small industrial plants in which one unit pulverizer serves each boiler; in this case, only one boiler is installed. A feature of this installation is the dual drive by motor and steam turbine, the latter exhausting to heating and process work. In all the other cases tabulated, pulverizers are driven by electric motors.

Figures were not given by all the stations on power consumption per ton of coal pulverized but the data given by several of them show interesting results. At least, they give some idea of the results obtained under the most recent practice. For pulverizing only, Cahokia consumes 15 kw-hr. per ton of coal, Horseshoe Lake 12 kw-hr. per ton and Toronto 15.8 kw-hr. per ton. For both pulverizing and transport, Gould St. gives 19.6 kw-hr. per ton.

Fineness of Pulverization

It is apparent from the table that most of the stations are not pulverizing coal to as great a degree of fineness as in former years. It seems to be generally accepted now that 65 per cent or thereabouts through 200 mesh is sufficient and that it is more important to have larger percentages pass through the larger screens until almost all the coal will go through 50 or 60 mesh. While it is realized that fine pulverization is most desirable from the combustion standpoint, the factors of turbulence of flame, wear on mills, furnace erosion and the like, materially affect the final result when the coal is actually burned in the furnace.

Turbulent Burners

Trend towards the use of turbulent burners is indicated more clearly this year than ever, especially in the unit mill systems. In some of the furnaces, such as the slag-tapping furnaces, as used at Toronto and Horseshoe Lake turbulent burners are used but at Hell Gate burners are set tangential to a circle in the furnace. In the steam generating unit at U. S. Rubber Co., burners enter at the corners of the furnace to give turbulent flame. A cylindrical furnace with burners arranged to give turbulence, as used at Columbia Station, will be described in the article on furnace construction.

Water-Cooled Walls with Stokers

As pointed out in the analysis of Dec. 15, 1927, increased use of water-cooled furnace walls has materially affected stoker design and applications. Stokers themselves show a decided tendency to increase in size, as far as their physical dimensions are concerned, although their size in relation to boiler heating surface remains about the same. This ratio, as tabulated for 10 stations using both chain grates and underfeed stokers, ranges all the way from 25.8 sq. ft. of boiler heating surface per square foot of grate area at Edgar

FUEL BURNING & PREPARATION

NAME OF STATION	FUEL						PULVERIZING MILLS						BURNERS		STOKERS			METHOD OF COOLING WALLS	AIR SUPPLY						ASH DISPOSAL	
																			PRIMARY			SECONDARY				
	B.T.U. AND KIND	METHOD OF FIRING	PREPARATION	TYPE DRYER	% MOISTURE INITIAL	% MOISTURE FINAL	TYPE	CAP. T/HR. EACH	NO. PER BLR.	DRIVE & POWER CONSUMED	FINES % THRU 200 M.		TYPE	NO. PER BLR.	TYPE	RATIO G'T BHS. TO G'RT.	DRIVE		% OF TOT.	WHERE INTRODUC'D	TEMP.	% OF TOT.	WHERE INTRODUCED	TEMP.	FURNACE	FLUE GAS
PHILO 1928 EXT.	OHIO 11,500	CHAIN GRATE	RING CRUSHER		8.0	8.0									CHAIN GRATE	41.2	D.C. MOTOR	WATER							SLUICE	
CAHOKIA 3RD SECTION	ILL. + W. KY 11,400	PULV. COAL	UNIT MILLS	NONE	8.0	8.0	PADDLE IMPACT	3.75	2	MOTOR 15 KW-HR/T.	65		TURBULENT	4				WATER	TO	AT MILL	240	30	AT BURNERS	240	SLUICE	
VIENNA, MD. STATION	W. VA. SLACK 14,800	STOKERS													UNDER-FEED	34.6	TURB.	WATER BRIDGE W. ONLY							SLUICE	
LONG BEACH NO. 3	OIL-18,500/LB. GAS-1200/CU.FT.	MECH ATOM-IZED	OIL HEATED										COMB. GAS + OIL-WIDE RANGE	20				WATER	15	AT BURNERS	471					WATER SPRAY IN AIR HEATER
KEARNY 1928 EXT.	LANCASHIRE 13,750-WET BASIS	STOKERS				38									UNDERFD. IS RETORT	45.8 †	4-SPEED A.C. MOTOR	WATER + SIDES OF FURN.							SLUICE	
BINGHAMTON 1928 EXT.	LUCERNE CO. SLACK 14,200	PULV. COAL	CENTRAL SYSTEM	COAL FIRED ROTARY	6.0	0.75	BALL-SCREEN	5	1	DIRECT CONN. MOTOR	75		TURBULENT ON 2 AND PLAIN ON 1	2 ON 1 3-1 1-1				2-WATER 1-AIR	10 TO 25	AT FEEDERS	235	90 TO 75	AT BURNERS	300	NARROW GAGE CAR	
HELL GATE 1928 EXT	W. VA. 14,000	PULV. COAL	UNIT SYSTEM	MILL			BEKIER	6	4	MILL MOTOR 125 HP. FOR 2 HP.	65		TANGENT	4 3 ELE. IN ER.				WATER	15	AT MILL	280	85	AT BURNER	280	SLUICE	SLUICE
SAGINAW R. 1928 EXT.	W. VA (SEE TEST)	STOKERS	CRUSHER		3.5										UNDER-FEED	32.0	3 SPEED A.C.	WATER + STEAM							SLUICE	
STATION C PG+E CO. 1928 EXT.	OIL 18,500/LB.	MECH ATOM. IN SUSPEN.											MECH WIDE RANGE	20				WATER								
HORSESHOE LAKE STA. 1928 EXT.	ANTH. 12,760 COKE 14,957	PULV. COAL	UNIT SYSTEM	MILL	7.3 5.6		AIR SEPAR-ATOR	7.5	2	VAR. SPEED IND.-12 KW-H PER TON	65		TURBULENT	4				WATER	21 3 18.0	AT MILL	300	78.7 82.0	AT BURNERS	335	SLUICE	
EDGAR 1928 EXT	NEW RIVER 14,050	STOKERS	BREAKERS	NONE	3.5	3.5									UNDER-FEED	25.8	IND. MOTOR	WATER	100	UNDER STOKER	401				DROPS TO TRUCKS	CINDER CATCHER
HUDSON AV. 1928 EXT.	PA SEMI-BIT R.O.M. 13,500	STOKERS													UNDER FEED	45.4	D.C. MOTOR	WATER							SLUICE	CINDER CATCHER
GOULD ST.	W.VA + PA. 14,090	PULV. COAL	CENTRAL SYSTEM	MILL *	6.0	1.7	AIR SEP.-ROLLER	20	2 TOT.	SQ. CAGE M 19.6 KW-H/T. INC. TRANSP.			FAN TAIL VERT	16				WATER		AT FEEDERS		PREHTR. AIR TEMPERED	FRONT WALL + AROUND + BURNERS		SLUICE	
TORONTO 1928 EXT	PITTSBURG NO. 8 11,690	PULV.	UNIT SYSTEM -	MILL	11	5.0	AIR SEP.	10	2	MOTOR 15.8 KW-HR. PER TON	65		CROSS TUBE	4				WATER	25 TO 30	AT MILLS	275	70-75	AROUND BURNERS	513	MOLTEN SLAG	
TRINIDAD	TEXAS LIGNITE 6490	PULV. COAL	CENTRAL SYSTEM	STEAM GRID	33.	28.	ROLLER	15	1	IND. MOTOR	65		FAN TAIL	12					20	AT BURNER	120	80		65	DRAG CONV.	
CRAWFORD 1928 EXT.	KINCAID 10,200	STOKER	CENTRAL SYSTEM-BREAKER	NONE	13.5 TO 15										CHAIN GRATE	5-41.2 +-41.0	VAR SPEED MOTOR	WATER							ASH PIT DUMP DIRECT TO RR CARS	
LAKE PAULINE	OIL-19,000/LB. GAS 1024/CU.FT.	SUSPEN-SION											COMB. GAS+OIL	9				AIR								
U. S. RUBBER CO.	KY. N.&S.	PULV. COAL	UNIT MILLS	MILL DRYING	3.5		HAMMER IMPACT	3.5	2	MOTOR	65		TURBULENT	8				WATER	15	AT MILL	475	85	AT BURNERS	475	SCREW CONV.	
ACHESON HARDEN CO.	14,700	PULV.	CRUSHED IN UNLOADING UNIT MILL	MILL			PADDLE	0.5	1	NON-COND. TURB. + AUX. MOT.	80-85 100 MESH		TURB.	1					80	AT MILL	131	20	AT BURNERS + REGISTERS IN WALL	82	MANUAL	
PISTON RING CO.	KY. 14,000	STOKER			3.0										SINGLE RETORT U-FEED	52.0	STM RAM ON STOKER		95	UNDER STOKER	90	5	OVER FIRE	125	STEAM JET	
ANGLO-CANADIAN	DOMINION SLACK 13,000	STOKER	CRUSHER ONLY	NONE											U-FEED	43.4	HYDRAULIC	WATER	100	STOKER WIND BOX					SLUICE	SLUICE
SORG PAPER CO.	KY	PULV.	UNIT SYSTEM	MILL			BALL	3.5	1	MOTOR	85		TURB	1				WATER	30	AT MILL	320	70	AT BURNER	320	SLUICE	CINDER TRAP
STANOLIND	CENT. ILL 10,355	PULV.	UNIT SYSTEM	MILL			IMPACT	7.5	2	MOTOR			TURB.	4				WATER + AIR	10	AT MILL	285	90	AT BURNER	230	SLUICE	

* - TUBULAR AIR HEATER USING STEAM AT BOILER PRESSURE HEATS AIR FOR DRYING MAINTENANCE OF PULVERIZING PLANT 13.9 CENTS PER TON

† - PROJECTED GRATE AREA, INCLUDING CLINKER GRINDER.

‡ - THIS IS REALLY TERTIARY AIR AROUND BURNERS

to 52.0 at Piston Ring Co. The latter installation is in a small industrial plant and the figure for heat release given in the table on furnace and draft practice is of interest when compared with that of the large central stations tabulated. Two chain grate installations, Philo and Crawford, have ratios of 41.2. The tabulated analysis includes typical stoker installations in both large and small industrial plants as well as central stations. The larger type of industrial plant is typified by the Anglo-Canadian Pulp & Paper Co.

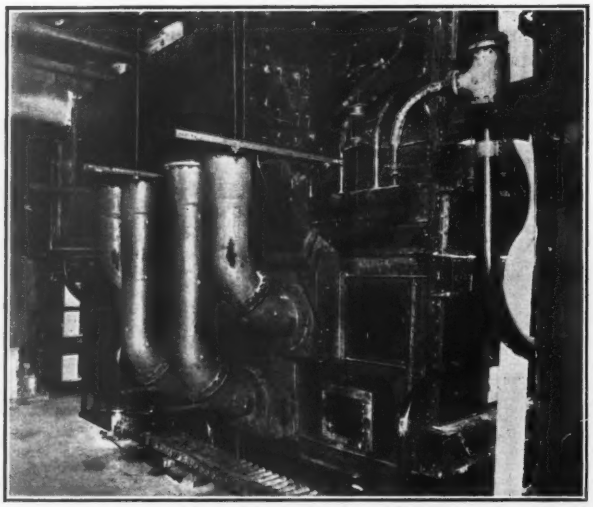


FIG. 2. FRONT OF FURNACE AT CAHOKIA SHOWING HORIZONTAL TURBULENT BURNERS FOR PULVERIZED COAL

Stokers 15 retorts in width as at Kearny and 45 tuyeres deep are in use in several installations and it is stated by manufacturers that larger ones can be furnished if they are demanded.

Further Refinement in Stoker Details

Attention was called last year to the various methods for securing better distribution of air under the fuel bed of the stoker. This trend has continued, with refinements in mechanism to obtain the desired result. In some cases, the air control mechanism operates automatically as part of the stoker; in other cases, the stoker windbox is divided into zones controlled by hand. In still others, air control is by the automatic combustion controls.

Of particular interest are the stokers installed at Hudson Ave. to serve the most recent boiler units. Each of these stokers consists of a 33-tuyere conventional underfeed area feeding onto a short length of what is essentially a chain grate, arranged to reciprocate up and down in sections with a wave-like motion, directing the coal to the clinker-grinder pit. Also, the front wall of the clinker grinder pit is of hard burned paving brick with a spray of cooling water falling over it. Four motors drive this arrangement: one drives the underfeed section proper, two drive the clinker grinder and a fourth the rocking grate section. Full windbox pressure is carried under the clinker grinder rolls to burn out combustible in the grinder pit and also to cool the rolls.

Clinker grinders in the type of central stations tabulated here are the rule rather than the exception and the same practice is followed in many larger industrial stokers.

Temperatures of Air for Stokers and for Mill Drying

While there is still controversy regarding temperature of preheated air both for stokers and for drying in the pulverizing mill, it will be noted in the accompanying tabulation that temperatures of air used for mill drying range from 285 to 475 deg. and one stoker uses air at 400 deg. Reference has been made to other stoker installations designed for operation with 600-700 deg. air. With stokers, the limiting consideration seems to be that of mechanical strains in the stoker. With pulverizing mills, the question of combustible mixture in the mill is most important, although many engineers maintain that there is little danger of this and it is known that accidents or serious trouble due to this cause have been extremely rare.

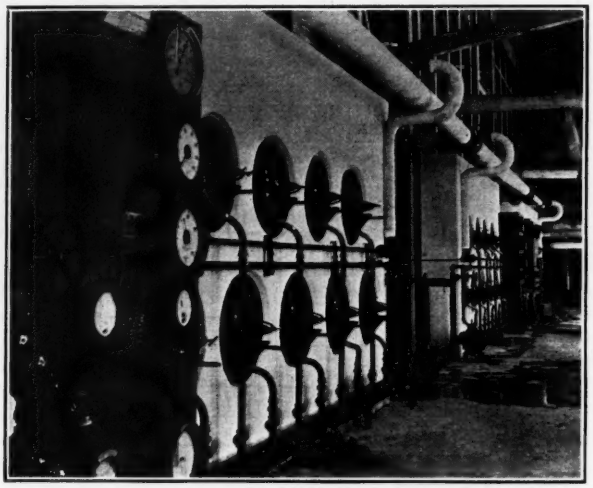


FIG. 3. FRONTS OF GAS-FIRED BOILERS AT LAKE PAULINE

Ash Disposal Methods

Disposal of ash in many of the plants tabulated here is by sluice, although mechanical methods are represented, such as the screw conveyors of U. S. Rubber Co., drag conveyors at Trinidad, and the direct loading of trucks from the ash pits as at Edgar and Crawford.

Elimination of the ash from the flue gas of pulverized coal plants is a serious problem in some plants and a minor one in others, depending on the location of the plant and several other factors. Numerous devices are being used to eliminate this ash and although there is little definite information available, it is felt that an entirely satisfactory solution of the problem will soon be reached. Some plants are using cyclones or traps of various kinds especially designed for the purpose. Others are using various types of induced draft fans designed to trap cinders. Still others are using washing devices.

It is obvious that no particular type of cinder or ash eliminator is applicable in all plants. The type used will depend upon the boiler and furnace equipment and upon the kind of fuel used.

Progress in Furnace Design and Draft Practice

DEVELOPMENTS OF 1928 INCLUDE WIDER USE OF WATER-COOLED FURNACE WALLS, ESPECIALLY WITH STOKERS, SLAG-TAPPING FURNACES, NEW FAN DESIGNS

OF THE TENDENCIES in furnace construction during the year, as shown by the accompanying tabulations, the most important seem to be increase in use of water-cooled furnace wall surface, especially with stokers, higher heat releases, frequent use of a new type of variable inlet draft fan, further applications of the slag-tapping furnace.

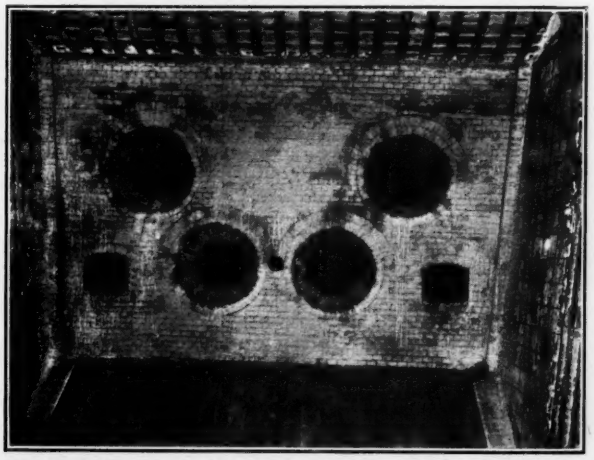


FIG. 2. LOOKING FROM INSIDE FURNACE AT FRONT WALL OF BOILER FIRED BY FOUR TURBULENT BURNERS

Study of the ratios of cubic feet of furnace volume to square feet of boiler heating surface, together with the values for heat liberated per cubic foot of furnace volume per hour, indicates that on the whole the averages are about the same as those of last year.

Two installations of chain grate stokers have a ratio of furnace volume to heating surface of 0.38 and 0.33 cu. ft. per sq. ft.; the range of ratio for all the stoker installations is from 0.22 at the Piston Ring Co. to 0.66 for Edgar. In the pulverized coal furnaces, the ratio ranges from 0.65 at U. S. Rubber Co. to 1.9 at Horseshoe Lake, but the average seems to be about 0.9. For the oil and gas burning furnaces, the ratios are 1.225 for Lake Pauline, 0.41 for Station C and 0.58 for Long Beach No. 3.

While the rates of heat release in these furnaces are, on the average, only a little higher than those attained last year, with furnaces of about the same relative sizes, there are several extremely important exceptions. One of these is Philo, with chain grate stokers, using preheated air and securing a heat release of 47,000 B.t.u. per cu. ft. of furnace volume per hour, in a water-cooled furnace, at 465 per cent of boiler rating. Station C, burning oil in a water-cooled furnace of 0.41 cu. ft. per square foot of heating surface, liberates 37,000 B.t.u. per cu. ft. per hr. at 375 per cent of rating. At Hudson Ave., with a furnace ratio of only 0.36, burning coal on a new design of underfeed stokers, the heat liberation is 60,600 B.t.u. per cu. ft. per hr. at 500 per cent of boiler rating.

The Anglo-Canadian installation secures a heat release of 41,000 B.t.u. per cu. ft. per hr. at 330 per cent of rating, with large underfeed stokers, water-cooled walls and preheated air. Of special interest is the performance of Piston Ring Co. Here single-retort underfeed stokers, in ordinary fire brick settings give a heat release of 44,000 B.t.u. per cu. ft. per hr., corresponding boiler rating being 200 per cent.

Many of the other stations have heat releases ranging between 20,000 and 30,000 B.t.u. at varying boiler ratings.

WATER-COOLED FURNACE INCREASE

Study of the tabulation and of the boiler cross-sections in Fig. 1 reveals the decided tendency toward water-cooled furnaces. There is still a field for the air-cooled furnace and several of these are represented, such as Binghamton No. 8 and Lake Pauline. Air-cooled

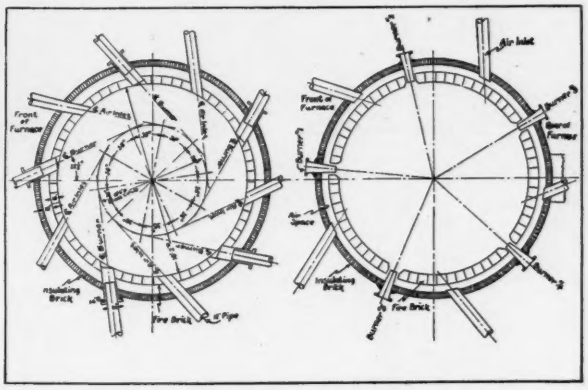


FIG. 4. LEFT—ORIGINAL ARRANGEMENT OF BURNERS IN CYLINDRICAL FURNACE, COLUMBIA STATION. RIGHT—PRESENT ARRANGEMENT OF BURNERS IN CYLINDRICAL FURNACE, COLUMBIA STATION

front walls or front walls and parts of side walls are sometimes used with water-cooled side and rear walls as typified by Gould St. and Trinidad. Such combination is sometimes dictated by combustion conditions, depending on fuel, type of boiler and similar factors, and sometimes by economic considerations of the cost of building and operating the furnace.

Water-cooled furnaces with chain grate stokers are typified in this analysis by such installations as Philo, where the cooling surface is 6.9 per cent of the total heating surface of the boiler, and Crawford.

With underfeed stokers, the proportions of water wall surface to boiler surface range from 5.7 per cent at Saginaw River to 19.45 per cent at Kearny. In the Kearny installation the water walls are of the bifurcated tube type up to the level of the first tube deck and from that point they extend upward the whole height of the furnace. This is the only stoker installation represented of this type; the others have side walls and bridge walls cooled only up to the lower boiler tube level.

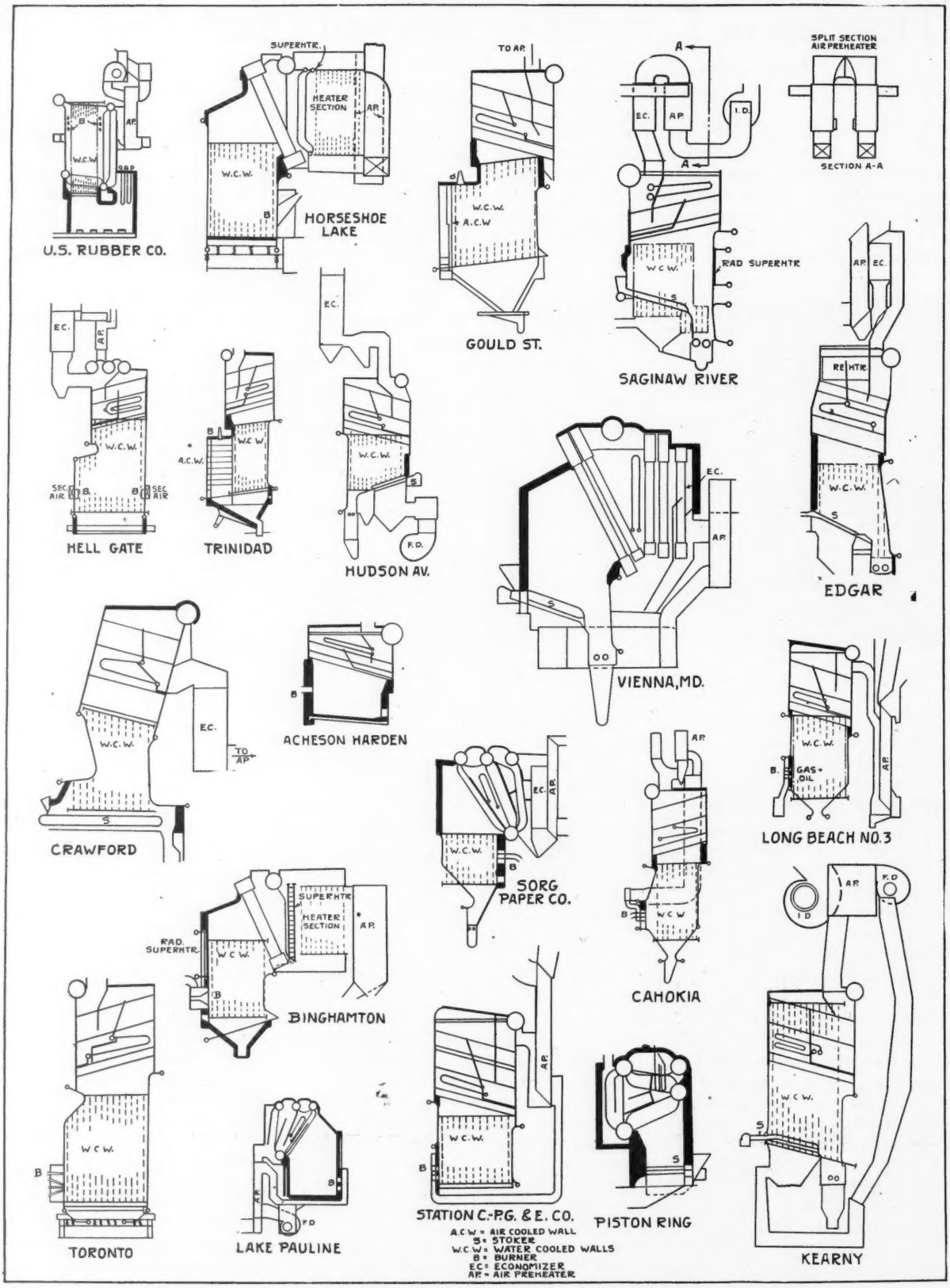


FIG. 1. DIAGRAMMATIC CROSS-SECTIONS OF BOILERS AND FURNACES NOTED IN TABULATION, TO SHOW RELATIVE LOCATIONS OF WATER-COOLED WALLS, BURNERS AND STOKERS, ECONOMIZERS AND AIR PREHEATERS

FURNACE AND DRAFT PRACTICE

NAME OF STATION	FUEL AND METHOD OF FIRING	RATIO FURN. V. TO B.H.S.	BTU LIBERATED/ CU.FT/HR.	CORRESPONDING BOILER RATING %	ARE ECON. USED ?	TYPE FURNACE WALLS	WATER WALL SURFACE % OF TOT	WATER WALL SURFACE □'/BLR.	HEARTH SCREEN □'/BLR.	FANS: CAP EA-C.F.M. F.D.	FANS: CAP EA-C.F.M. I.D.	FANS: TYPE F.D.	FANS: TYPE I.D.	FANS: NO/BLR. F.D.	FANS: NO/BLR. I.D.	FANS: DRIVE F.D.	FANS: DRIVE I.D.	FANS: R.P.M. F.D.	FANS: R.P.M. I.D.	FANS: STAT PR "H.O. F.D.	FANS: STAT PR "H.O. I.D.	AIR PREHEATERS: TYPE	AIR PREHEATERS: NO. PER BLR.	AIR PREHEATERS: HEATING SURF.□'	AIR PREHEATERS: CAP #AIR/HR. EA.	AIR PREHEATERS: AIR TEMP. IN	AIR PREHEATERS: AIR TEMP. OUT	AIR PREHEATERS: GAS TEMP. IN	AIR PREHEATERS: GAS TEMP. OUT	CHIMNEY HEIGHT + NO. BLR./ CHIMNEY
PHILO 1928 EXT.	NO. 6 OHIO FORCED DRAFT CHAIN GRATE	0.38	47,000	465%	YES	CAST BLOCK WATER COOLED	6.9	1597		50,000	175,000	TURBOVANE VARIABLE INLET		2	1	3 SPEED SQ. CAGE MOTOR		575 860 1160	435 690 860	3.9 7.6 8.6 12.8 15.8	2.44 6.30 10.27	PLATE	1	51,000	311,200	100	519	745	356	3-185'
CAHOKIA 3RD. SECTION	ILL. + W. KENTUCKY BITUMINUS PULV. COAL	0.67	13,000 TO 27,000	200 TO 400	NO	WATER TUBES RECESSED INTO REFRACTORY, PROTECTED BY BLOCKS IN PIT	7.9	1275	NONE	65,000 PER BLR.	180,000 PER BLR.	TURBO-VANE	MULTI-VANE	2	1	SLIP RING MOTOR		1100	680	6.5	6.0	PLATE	1	9,920	300,000	70	290	615	400	4-265' ABOVE ROOF
VIENNA, MO. STATION	W. VA. OR PA STOKERS	0.628	30,700	400	YES	PROTECTED BLOCKS ON BRIDGE WALL, BALANCE PLAIN BRICK	13.6	133		32,000	80,000	TURBOVANE VARIABLE INLET		2	1	DUAL MOTOR DRIVE EACH CONSTANT SPEED		1165 865	870 580	6.0	3.75	PLATE	1	6,624		70	366	675	478	2-68' ABOVE GRATE
LONG BEACH NO. 3	OIL + NAT. GAS MECHANICAL ATOMIZED	0.58	18,500	322	NO	REFRACTORY FACED WATER COOLED	9.4	3240		53,000	180,000	RADIAL FLOW DOUBLE INLET		2	1	COMMUTATOR TYPE A.C MOTORS		1204	630	10.0	7.3	TUBULAR	1	51,232	354,800	80	471	650	325	2-226' ABOVE BLR. RM. FL.
KEARNY 1928 EXT.	LANCASHIRE BIT UNDERFIRED STOKERS	0.385*	30,400	300	NO	BIFURICATED TUBES WATER COOLED	19.45	5536†		113,000 TO[2]	210,000 TO 450	RADIAL FLOW BACKWARD TIP BLADES	RADIAL FLOW RADIAL TIP BLADES	1	1	2-SPEED SLIP RING MOTORS		1175	575	14.25	6.0	ROTARY ELEMENT WITHOUT FANS	2	45,700 EACH	227,000 MAX.	70	490	755	450	6-250' ABOVE GRATES
BINGHAMTON 1928 EXT.	LULERNE COUNTY PULVERIZED COAL IN SUSPENSION — BLR. NO. 9	0.83	25,000	500	HEAT SECTION OF BLR	FIN TUBE WATER COOLED	44	916	175	28,000	46,000	TURBOVANE	MULTI-VANE	2	2	SQ. CAGE IND. MOTOR	SLIP RING IND. MOTOR	1750	860	7.5	6.5	PLATE	2	12,000 PER BLR.	157,000 PER BLR.	70	325	575	360	2-100' ABOVE GAS OUTLET
	" 10	0.96	23,200	500	DO.	PROTECTED BLOCKS WATER COOLED	69	1199	468																					
	" 8	0.85	16,500	316	EXTENDED SURF ECON	SUSPENDED AIR COOLED SIDE WALLS, WATER CLD. BRIDGE W + FURN. BOTTOM	19.6	340	305	NONE	33,700	NONE	MULTI-VANE		2		DO.		860		6.5	NONE								NO. 8 DISCH. TO STACK WITH NO. 7
MELL GATE 1928 EXT.	POCAHONTAS PULVERIZED	0.90	31,000	720*	YES	FIN TUBE WATER COOLED	16.0	3800	400	155,000	275,000	TURBOVANE WITH VARIABLE INLET VANE CONTROL		1	1	SQ. CAGE 3-SPEED		870 MAX		10.	14.	PLATE	1	18,840	456,700	70	286	820	484	6-175' ABOVE BREECHING
SAGINAW RIVER 1928 EXT. 30,000 KW. UNIT	W. VA. UNDERFEED STOKERS	0.48	28,000	350	YES	WATER COOLED TUBES WITH C.I BLOCKS SHRUNK ON	5.7	749		55,000	90,000	PROPELLER INTEGRAL WITH AIR PREHEATER		1	1	SLIP RING MOTORS		600 TO 1200		8.3	6.6	ROTARY ELEM.	1	56,000	220,000	80	335	445	240	1-90' ABOVE GRATE
35,000 KW. UNIT	DO	0.48			YES	BARE TUBES 6" CENTERS TILE BETWEEN TUBES	5.7	749		VALUES PROBABLY WILL BE SAME AS FOR 30,000 KW. UNIT												PLATE SPLIT SECTION TYPE	1	12,000						
STATION C P.G.+E. CO. 1928 EXT.	OIL MECHANICAL ATOMIZATION	0.41	37,000	375	NO	WATER COOLED REFRACTORY BLOCKS	4.75	1674		125,000	210,000	TURBOVANE WITH VAR. INLET VANE CONTROL		1	1	2-CONSTANT SPEED INDUCTION ON EACH 2300 V.		860	670	15.	8.5	TUBULAR	2	52,000	424,000	80	488	700	343	2-150'
HORSESHOE LAKE STA. 1928 EXT.	SEMI-ANTHRACITE OR PETROLEUM COKE PULVERIZED	1.9	23,000	250,000 LB/HR	YES	REFRACTORY FACE BLOCKS-WATER COOLED	16.6	1693		60,000	100000	DOUBLE INLET DUPLEX CONOIDAL		2	2	2300 V. SLIP RING MOTORS		1145	845	8.5	5.5	TUBULAR	1	22,000	514,260	80	335	560	330	1-150'
EDGAR 1928 EXT.	NEW RIVER U-FEED STOKERS	0.66	18,000	300	YES	WATER COOLED		1235		47,500	66,000	HORIZONTAL DOUBLE INLET		2	2	2 VAR. SPEED SLIP RING MOTORS EACH		1175	1175	11.2	11.75	TUB.	1	33,082	206,000	80	401	612	339	4-220 ABOVE GRATES
MUDSON AV. 1928 EXT.	PA SEMI BIT STOKERS	0.36	60,600	500	YES	C.I REFRACTORY BLOCKS WATER COOLED	5.26	1326		120,000	105,000	TURBOVANE WITH VAR. INLET VANE CONTROL		1	2	CONST. SPEED SQ. CAGE MOTOR	2 SPEED SQ. CAGE MOTOR	870	1160 TO 600	8.5	15.5									4-350' 4-FUTURE
GOULD ST.	W. VA + PA PULV. COAL	0.796	33,300 MAX	550 MAX	NO	FIN TUBE WATER COOLED		2009	641	75,000 PRI. AIR 10,000	135,000	NOT GIVEN		2 1	2	POLE CHANGER WOUND ROTOR SLIP RING WOUND ROTOR		1200 600 700 1800	900 450	10.5 20	15.8	PLATE	1	26,772						1-213' ABOVE BURNER ARCH
TORONTO 1928 EXT.	PITTSBURGH NO. 8 PULV.	0.87	25,700	458	NO	FRONT WALL AIR COOLED NO 7-C.I BLK. W NO 8 - BARE TUBES W.C	11.8	2736		108,000	160,600	NON-OVER LOADING MP CHARACTERISTIC	STRAIGHT BLADE SIROCCO WHEEL	1	1	2 SPEED MOTORS		900 600	515 257	8.65	8.3	PLATE	2	36,720 TOTAL	413,000	100	513	820	446	1-170'
TRINIDAD	TEXAS LIGNITE PULV.	0.871	14,300	272	NO	WATER AND AIR	8.5	1805	715	PRI. AIR 13,500				PRI. AIR 1		2200 V. INDUCTION MOTOR		1760												2-386 ABOVE THE GROUND
CRAWFORD 1928 EXT.	KINCAID CHAIN GRATE STOKER	0.33		200,000 LB/HR. NORMAL	YES	SIDE WALL WATER COOLED PROTECTED BLOCKS				90,000	125,000	CONOIDAL	MULTI-VANE	1	1	2 SPEED MOTORS		875 690	575 420	4.5	6.0	PLATE	1 1	16,000*6 17,780-*6	244,000	70	283	525	333	12-215' ABOVE GRATE
LAKE PAULINE	GAS WITH OIL FOR STANDBY	1.225	12,500	300	NO	AIR COOLED SUSPENDED WALL				38,750	58,700	TURBOVANE	MULTI-BLADE RADIALLY CURVED	1	1	SLIP RING MOTORS		690	860	3.0	5.0	TUB.	1	11,222	142,000	70	420	700	415	3-101'
U.S. RUBBER CO.	KY. N +S PULVERIZED	0.65	27,700	100,000 LB/HR	NO	FIN TUBES (STEAM GENERATOR)	28	1682	1334	37,800	60,000	CINDERVANE		1	1	SLIP RING MOTORS		1150	486	6.4	5.0	PLATE	1	15,552	112,000	70	530	670	325	4-200'
ACHESON HARDEN	REVLOC	0.164	8,230	212	NO	FIRE BRICK HIGH TEMP CEMENT HOLLOW FLOOR				NONE INSTALLED - NATURAL DRAFT CHIMNEY AND BLAST FROM PULVERIZER EXHAUSTER																				1-100'
PISTON RING CO.	KY. N.P. +S UNDERFEED STOKERS	0.22	44,000	200	NO	FIRE BRICK				20,000 FOR 3 BOILERS				1 FOR 3 BLRS.		STEAM ENGINE		VARIABLE		40										2-195'
ANGLO-CANADIAN	DOMINION SLACK STOKERS	0.315	41,800	330	NO	WATER COOLED	4.5	565.5		45,000	85,000	TURBO-VANE	CINDER VANE	1	1	CONST SP MOTOR	2 SPEED MOTOR	1165	695	8.7	5.0	TUBULAR	1	13,313	203,000	70	354		400	3-225'
SORG PAPER CO.	KY. BITUMINOUS PULVERIZED	0.75	25,600	485	YES	WATER COOLED REFRACTORY BLOCKS		530		11,300	120,000	STEEL PLATE	DOUBLE INLET	1	1	SLIP RING MOTOR	SQ. CAGE MOTOR	690	545	5.0	6.5	TUB.	1	7,350	120,000	116	319	386	282	1-75'
STANOLIND	ILL. CENT COAL OIL & GAS PULV. COAL	0.89	19,200 MAX	400	YES	FIN TUBE WATER CLD. SIDE WALLS - AIR COOLED FRONT WALLS	12.82	2250		97,500	106,200	DUPLEX CONOIDAL		1	1	SLIP RING MOTOR		875	875	7.25	10.5	PLATE	1	10,584	277,000 222,000	100 100	260 235	484 408	336 286	2-180'

*-FURNACE VOL. IS EXCLUSIVE OF 1ST PASS AND ALLOWS FOR A FOOT OF COAL ON THE STOKER TUYERES +- WATER WALL SURF. INCLUDES WATER WALLS AT SIDES OF BLR. ABOVE FURNACE. #-INCLUDING ECONOMIZER + AIR HEATER

In the pulverized coal furnaces, water-cooled wall surfaces vary between 7.9 per cent of boiler surface and 19.6 per cent. In the U. S. Rubber Co., steam generating units the percentage of water-cooled surface is 28. Lake Pauline, burning oil, has air-cooled walls and Station C, burning oil, has 4.75 per cent of the boiler surface in water cooled walls.

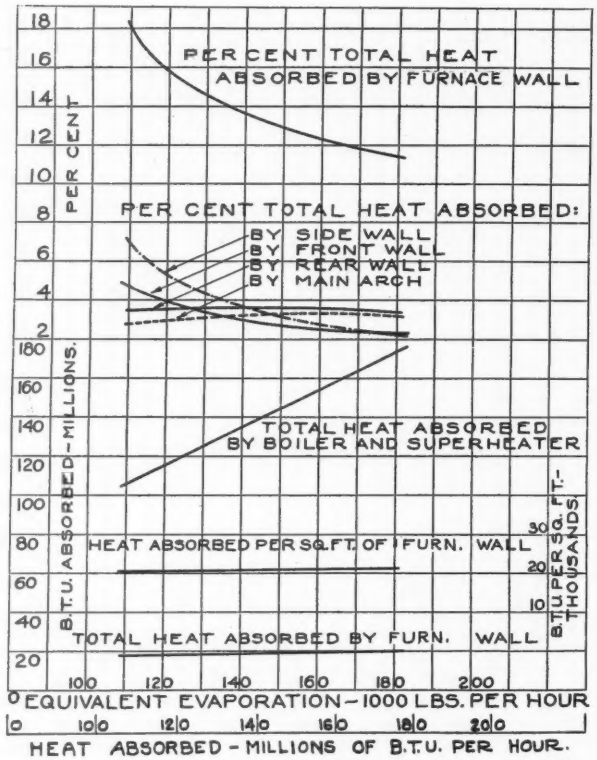

PER CENT TOTAL HEAT ABSORBED BY FURNACE WALL
PER CENT
PER CENT TOTAL HEAT ABSORBED:
BY SIDE WALL
BY FRONT WALL
BY REAR WALL
BY MAIN ARCH
TOTAL HEAT ABSORBED BY BOILER AND SUPERHEATER
B.T.U. ABSORBED - MILLIONS.
HEAT ABSORBED PER SQ.FT. OF FURN. WALL
B.T.U. PER SQ. FT. - THOUSANDS
TOTAL HEAT ABSORBED BY FURN. WALL
EQUIVALENT EVAPORATION - 1000 LBS. PER HOUR
HEAT ABSORBED - MILLIONS OF B.T.U. PER HOUR.

FIG. 5. HEAT TRANSFER CONDITIONS, UNIT NO. 4, BOILER NO. 5, CRAWFORD AVENUE STATION

Use of the radiant superheater as part of the furnace wall, usually behind the water wall, is illustrated by the arrangement used at Saginaw River. At Binghamton, on Boilers 9 and 10 a radiant superheater is set in the front wall of the furnace, but without protecting tubes in front of it. Water-cooled bridge walls or rear walls with stokers are common.

Hearth screens are used at Gould St., Trinidad and Binghamton and U. S. Rubber Co. Other stations such as Sorg Paper Co., Long Beach and Cahokia use what is usually termed the water-cooled hopper bottom. The Hell Gate furnaces now under construction appear on Fig. 1 to have flat bottoms; this is not the case, however, as they have ash hoppers at right angles to the section shown. It was thought that the section used showed more of the important details of the setting than a section showing the ash hoppers.

Two of the sections, however, show the extremely interesting furnaces in the latest Toronto extension and the latest Horseshoe Lake extension. These have flat bottoms designed to hold the ash and slag in molten form so that it can be tapped off in this condition into a sluice, where it is immediately cooled and broken up in a fine granular form. Owing to the fact that furnaces of this type must be tight at the bottom and that the furnace walls are water-cooled, some method must be devised for taking up the vertical expansion of the furnace. This is done by supporting it on springs, as shown.

Use of the flat furnace bottom in oil- and gas-burning installations such as Lake Pauline and Station C has been common practice and is done for different purposes from those noted above. At Long Beach No. 3, however, it will be noted that the water-cooled hopper bottom is used, representing some divergence from the other two.

Another furnace that has aroused considerable interest, although it is not shown in the tables, is the cylindrical furnace recently put in operation at Columbia, shown in Fig. 4. This furnace has suspended air-cooled walls and a volume of 8000 cu. ft. and was installed under one of the 15,110-sq. ft. standard boilers. Originally the burners and air jets were set as shown at the left of Fig. 4 but in operation with this arrangement it was found that the flame traveled too close to the walls causing the brickwork in the burner zone to become too hot, with little combustion taking place in the center of the furnace. After some experimenting, radial burners with deflectors were installed as shown at the right and more satisfactory performance was obtained. With this arrangement, normal heat liberation, based on the volume above the ash pit, is 22,000 B.t.u. per cu. ft. per hr., as compared with the normal heat liberation of 13,500 B.t.u. per cu. ft. per hr. in the rectangular furnaces.

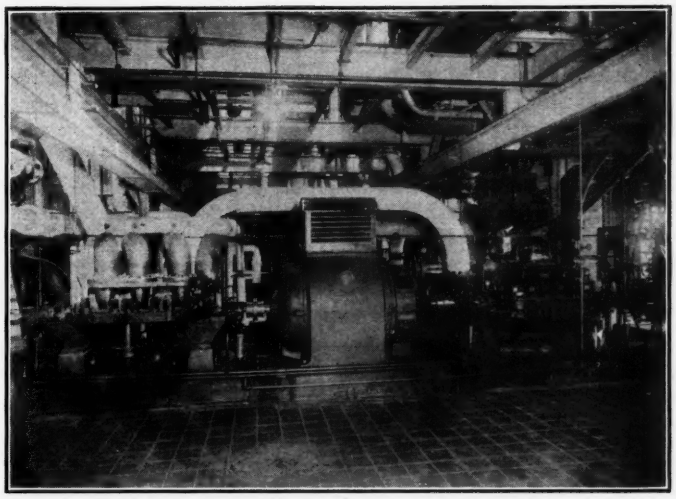
New Type of Fan

Several of the stations tabulated are using in their latest extensions a new type of forced and induced draft fan, described in detail in the October 15, 1928, issue of Power Plant Engineering. This fan, in brief, is designed so that the rotor is driven at constant speed by constant speed motors, to eliminate some electrical complications and permit higher motor efficiencies, while the air or flue gas is guided into the inlet side of the fan through movable vanes that swirl it in the direction of the fan's rotation. This action is designed to reduce inlet losses and at the same time, by movement of the vanes to various angles, to control volume and pressure of delivery. In some cases, a duplex drive is used, consisting of a large motor for one constant speed and peak loads and a smaller motor for lower speeds at normal operating loads. This is the type of fan used at Station C, Vienna and others.

Air Preheaters

In almost every station tabulated here, air preheaters are used either alone or in conjunction with economizers. Kearny uses rotary element type heaters with separate fans. The boilers for the 30,000-kw. unit at Saginaw River use rotary element type preheaters but with the boilers for the 35,000-kw. unit under construction, a split section type of plate preheater will be used as shown on Fig. 1. The remaining preheaters tabulated are either of the plate or tubular type.

Temperatures to which air is preheated for stokers vary from over 500 deg. at Philo down to 283 at Crawford, but at Philo this air is tempered before it goes to the stokers by an air-water economizer. For introduction to pulverizing mills for drying, air has been used at 500 deg. with no trouble.



Boiler Sizes and Pressures Still Increase

ANALYSIS OF TRENDS IN STEAM GENERATING UNITS, SUPERHEATERS AND ECONOMIZERS INDICATES CONTINUED ADVANCE TOWARD LARGER UNITS AND HIGHER PRESSURES. PRESSURES OF FROM 300 TO 500 LB. ARE COMMON AND A NUMBER OF PLANTS OPERATE AT OVER 600 LB. PRESSURE. BOILER EFFICIENCIES OF 89 PER CENT ARE OBTAINED IN SOME CASES. TEMPERATURES HAVE NOT INCREASED BEYOND 750 DEG.

BOILER UNITS INSTALLED during the past year indicate a continued tendency toward larger sizes. This is accompanied by a decrease in station investments per unit of capacity and offers possibilities of higher fuel economies, lower maintenance costs, greater ease of operation and improved methods of control that can never be obtained in small plants, since refinements that would result only in fractional addition in efficiency are justified in large size units where they could not be considered in connection with small units. Two of the plants listed report a heating surface of over 34,000 sq. ft.

Efficiencies and Capacities Reach High Figures

Boiler efficiencies of 89 per cent are being attained in several plants and enormously increased outputs per sq. ft. of heating surface and of floor space occupied are now possible. Boiler units capable of supplying 400,000 lb. of steam per hour are now available. Increase in size is not confined to boilers designed for any particular kind of fuel. All classes of boilers are involved.

Extension of the use of water walls in various types making possible the efficient use of radiant heat has aided much in increasing evaporative efficiencies and capacities. Especially is this true where pulverized coal is employed as fuel, since more radiant heat is emitted and may be absorbed from flames of a pulverized coal furnace, due to the large volume of flame of greater luminosity than is the case with a stoker-fired furnace.

Water Wall Heating Surface

High rates of heat absorption by water in water walls with the consequent high circulation velocities have made necessary extreme care to avoid circulation difficulties which have appeared in several instances but these have been overcome by balancing velocities between the water walls and the boiler proper. One instance is reported of severe water hammer when blowing down water walls after they had cooled; no trouble has appeared when the walls have been blown down shortly after being cut out.

During the past year, a new type of solid water wall has been brought out which presents a solid water-cooled surface to the furnace, storing a large amount of water. Use of seal welding for the purpose of maintaining tight joints under high pressure is made at the Long Beach station on all joints in the boiler water wall piping where a leak would cause a boiler shut down.

Pressures ranging from 300 to 500 lb. are now common: Three of the plants listed operate under pressures exceeding 600 lb.: One reports a pressure of 1415 lb. Tendency toward the use of higher steam pressure is still indicated. This is true not only in the central station but also in the industrial field. Operators report both thermal and commercial economy in the use of higher pressures.

High Pressure Operation

Operating troubles, so far as heat absorption or transmission is concerned, appear to be no greater with high pressures than with the ordinary 200 lb. pressure so long standard. No difficulty appears in handling high-pressure steam with apparatus of the conventional type when it is made proportionately heavy. The type of gage-glass may have to be changed, boiler feed pumps may give trouble or difficulties may be experienced with the economizer section, but not with the strictly boiler portion. On the other hand, some operators report an increase in steadiness of action where higher pressures are employed.

While reports of ultimate steam temperatures of over 750 deg. F. continue to come from abroad, this temperature seems still to be the maximum regularly used in this country. Temperatures of over 750 deg. have occurred in several plants for short periods where conditions of operation have resulted in temperatures higher than those for which the apparatus was designed.

As high as 1200 deg. F. at 350 lb. pressure was required for one small separately fired superheater. A general advance over 750 deg. F. is anticipated as soon as valves, fittings and turbines are designed for higher temperatures. High temperatures have not been confined to large central station installations but have been specified for all classes of boilers including waste-heat types.

BOILER, SUPERHEATER & ECONOMIZER DATA

NAME OF STATION	BOILERS															SUPERHEATERS								ECONOMIZERS							
	NO.	HEAT'G SURF. SQ.FT.	ABS PRES	NO. PASSES	FURNACE VOL. CUBIC FEET	FURNACE VOL. CU.FT./ □' W.H.S.	F.W. CONTROL METHOD	F.W. CONTROL NO/BLR	SOOT BLOW'G METHOD	SOOT BLOW'G #ELE./B.R	TUBES WIDE	TUBES HIGH	DRUMS NO.	DRUMS TYPE	DRUMS STEAM DIA"	DRUMS STEAM LENGTH	TYPE	HEAT'G SURF. PER BOILER SQ.FT.	HEAT'G SURF. PER BOILER %B.H.S	ELEMENTS DIA. INCHES	ELEMENTS B.W.G. NO.	TEMP °F. SUPER HT. °F.	TEMP °F. TOTAL	CORRESPONDING BLR RAT'G	TYPE	SURFACE SQ.FT./BLR.	SURFACE % OF BLR. HTG. SURF.	LOCATION	TEMP. WATER IN	TEMP. WATER OUT	TEMP. GAS IN	TEMP. GAS OUT
PHILO 1928 EXT.	6	4-21,551 2-5933	747	2	8166	0.353	AUTOMATIC	1	AIR MANUAL	16	38	22-2" 8-3⅛	1	CROSS	48	33'-6½"	CONVECTION			2	8	252	750	393	AIR WATER	15,772	4.05	BACK OF BOILER	320	369	536	369
CAHOKIA 3RD. SECTION	3	18,010	350	3	12,000	0.67	AUTO	2	STM MAN.	20	38	20	1	CROSS	60	31'-8"	CONV. INTERDECK	3789	21	2		300	725	250								
VIENNA, MD. STATION	3	6,330	370	1	3,971	0628	AUTO.	1	STM AUTO.	4			1	CROSS	48	16'-6"	CONV.					250	680	300	INTEGRAL	1,366	21.6	BACK OF BLR.				
LONG BEACH NO. 3	3	34,162	460	3	19,800	1.72	AUTO	2	STM	2 SETS OF 10	51	26	1	CROSS	60	34'-2¾"	CONV. INTRDK.	6,553	5.19	2	10	294	750	322								
KEARNY 1928 EXT.	3	22,900	415	3	8812 ①	0.31 W WALL 0.585 BLR. H.S.	AUTO	2	STM MAN	16	62	22	1	"	54	33'-11"	CONV.	4.350	18.99	1⅞	10	280	725	300								
BINGHAMTON 1928 EXT.	2	9,870	465	1	1-8200	0.83	"	1	STM AUTO.		36	22	1	"	48		CONV. RAD. CON.					275	725	315	EXTEN. SURF. PLAIN TUBE	4180	86.5	BACK OF BLR.	212	342	740	362
	1	10,620	463	3	1-9000	0.91		2	STM. MAN.	14	35	20	4		42		CONV.					275	725	500	PLAIN TUBE	5800	143					575
HELL GATE 1928 EXT.	3	23800	315	3	18,000	0 90	"	2	STM. MAN.	16	56	20	3	"	54	24'-6"	CONV.	4800	24	1⅞	9	314	735	720	TUBULAR	26,136	130	BACK OF BLR.	210	308	820	332
SAGINAW RIVER 1928 EXT.	4	12,340 B.H.S. 749 W.W.H.S.	415	3	6,000	0.46	AUTO. OR MAN.	1	STM MAN.	16	36	14	1	"	54	28'-2⅞"	CONV. + RAD.	5556 1485	43.5			283	725	350	STEEL TUBE	4,800	36.4	ABOVE BLR	200	283	690	445
STATION C PG+E.CO. 1928 EXT.	2	35,453	465	3	14,600	0.39	AUTO.	2	STM. AUTO.	20	51	24	1	"	60	34'-2⅞"	CONV	6,553	18.5	2	10	274	730	375								
HORSESHOE LAKE STA. 1928 EXT.	2	6,580	340	1	12,500	1 9	AUTO. OR MAN.	1	STM. AUTO. OR MAN.	6	50	9	1	"	48	28'-0"	CONV.	6,500	99.0	1.5	12	295	725		PLAIN TUBE	8,620	131	BACK OF BOILER	220		1180	560
EDGAR 1928 EXT.	2	15,093	1,415	3	4996		AUTO	2	STM	3	UPPER DECK 80 LOWER 40	DECK 10 DECK 8	1	"	48	38'-4"	INTRDK.	3483	23.1	2	4	155	733	500	HORIZONTAL STL TUBE	5,596	37.1	ABOVE BLR.	420	469	765	612
HUDSON AV. 1928 EXT.	4	23,764	465	3	8.500	0.339	AUTO	2	STM. AUTO	6	44	20	1	"	54	32'-1¼"	INTRDK.	3037	12.8	2	10	277	725	496	RETURN BEND	14,975	63	ABOVE BLR.	268	380	755	412
GOULD ST.	2	29,069	465	3	21,000	1	AUTO.		STM. AUTO.				1	"	60	34'-0"	4 LOOP INTRDK.							550								
TORONTO 1928 EXT.	2	20.468	440	3	17,758	0.765	AUTO	2	STM. MAN.	20	39	20	1	"	54	30'-11"	INTRDK. CONV.	4,260	21	2	11	277	725	458								
TRINIDAD	4	21,276 INC. WALLS + SCREEN	405	3	18,540	0.781	AUTO.	2	STM + AIR	22	44	18	1	"	54	33'-9¼"	CONV.	4,000	21.3 BASED ON B.H. SURF ONLY	2	10	305	750	277								
CRAWFORD 1928 EXT.	NOS 1-5	17,280	665	1	5,730				STM. MAN.	24	40 40 "	9 17	1 1	"	48	33'-8¼"	CONV.						750		LOOP COUNTERFLO	7,376 6,943	42.7 40.1	BACK OF BLR.				
	" 6-6	17,280	665	1	5,730																											
LAKE PAULINE	3	10,012	430	4	12,278	1.225	AUTO	2			36		4	"	42	23'-9"	CONV.					250	700	300								
U.S. RUBBER CO.	7	10,010	220	3	2500	0.25	AUTO	2	STM.	5	35		4	"	42	18'-10"	CONV.	1000	10	1.5	10	15	538	200								
	2	5,950	220	1	3860	0.65					21				48 31.5	16'-4"		1940	33		9											
ACHESON HARDEN	1	2010	140	3	1,223	0.608	AUTO.		AUTO.	5	14	10	1	"	54	8'-2"	CONV.	155	7.7	2	11	150	527	110								
PISTON RING CO.	2	2.555	140	3	450	0.384	AUTO.	1	STM	6	15	6	4	"	36	10'-0"	CONV.			1.5		150	530	200								
ANGLO-CANADIAN	3	12,533	410	3	3,950	0.301	AUTO.	1	STM. AUTO.	8	27	20	3	LONGITUDE INDIVIDUAL	42	25'-11¾"	INTEGRAL					100	540	250								
SORG PAPER CO.	3	6,790	430	3	4,300	0.75	AUTO.	1	STM MAN.	8	22		4	CROSS	42	12'-9.5"	CONV.	1548				250	725	300	STEEL TUBE	2,969		BACK OF BLR	177	291	669	387 ②
STANOLIND	4	17,596	415	4	15,620	0.84	AUTO	1	STM	14	55		4	"	42	31'-7"	CONV.	3,365	19.2	2		200	650	400	PLATE	8,136	46.3	BACK OF BLR	200	344	865	484 ③
	4		155															1,682	9.6			115	475	350						304	730	408

① FURNACE VOLUME IS EXCLUSIVE OF FIRST PASS AND ALLOWS FOR A FOOT OF COAL ON THE STOKER TUYERES

② AT 400% RATING ON M.P. BOILERES
③ AT 350 " " " L.P. "

Ratios of furnace volume to water-heating surface are lower than those reported last year indicating a tendency toward more rapid heat production. The ratios given in the table range from 0.301 in the Anglo-Canadian Station to 1.9 in the Horseshoe Lake plant.

Automatic Feedwater Control

Feedwater control is now almost universally automatic in large power plants. One of the weaknesses of feedwater control, heretofore, was that it has been based upon water level in the boiler drum alone. A sudden failure of air supply to the furnace will cause a reduction in the water level in a boiler drum resulting in shrinkage of the water and steam mixture. This will cause the feedwater regulator to open the valves wide until the proper level is reached. When the rate of steaming is again restored, the water level in the drum will then be too high and there is danger of flooding the steam line. Regulators are now being offered in which water flow is controlled by the rate of steaming, provided the water level is maintained within certain minimum and maximum limits.

Increase in pressures has led to two stage pumping of boiler feedwater, as employed at the Edgar Station where the feed pump is direct connected to a 2000-hp. motor shown in the headpiece of this article. At the right will be seen the low-pressure pump which forces the feedwater at 425 lb. press. into a pump header whence it is drawn into the high pressure pump at the left which delivers it to the boiler at 1600 lb. pressure.

High Steam Rates Change Former Ratios

Ratio of water storage capacity and steam liberating surface to the evaporating surface of a boiler that was considered adequate in boilers operated under low rate conditions is now being found insufficient under the present high rates of driving. This is particularly true under conditions of fluctuating load and irregular combustion.

Several of the plants listed have boilers which were designed for four drums. With large storage capacity it is possible to increase temporarily the output of the boiler without a corresponding increase either in combustion rate or in amount of feedwater. This is of value in taking care of emergency conditions such as those caused by sudden load demands and by the dropping of a boiler. In addition, the hazard due to failure of boiler feed supply is lessened.

Importance of Clean Heating Surfaces

Control of soot blowers used in the plants investigated seems to be almost evenly divided between manual and automatic with a slight preponderance in favor of the former method. The number of elements adopted per boiler varies greatly from 3 to 24 with the various plants but preference is given to a large rather than to a small number of elements indicating an increased tedency toward cleaner tubes.

There is, however, a sharp difference of opinion as to the importance of soot blowers in the first pass where the service is most severe. One operating company reports that in its latest installation, soot blowers for interdeck superheaters only are to be installed. They found that such soot blowers prevent accumulation of loose dirt in the gas passages of the superheaters and thus keep down resistance to the flow of the gases and permit maintenance or high total steam temperatures.

Soot blowers are now being applied also to economizers, as in the Long Beach station. Application of soot blowers to air heaters is also a decided trend. A special blower element used with the automatically valved soot blower head has been employed in some cases, particularly with heaters of the tubular type.

Most of the boilers considered are fitted with a single cross drum only. The present limit to diameter appears to be 60 in. and only one station, that of Edgar, reports a length over 34 ft. Most of the drums measure from 30 to 34 ft.

Radiant Heat Absorption

Inspection of the table shows a predominance of convection type superheating surface although some plants report the use of radiant heating especially in combination with convection heating. A wider application of radiant heat may be expected. Radiant superheaters have passed through several years of development; superheaters of this type using forged steel elements and large end clearances have been reported as requiring no excessive maintenance.

Drooping temperature characteristic of the radiant type superheater and the fact that for large boilers a considerable portion of the furnace wall surface must be water-cooled, had led many companies to adopt either additional convection superheater surface in series or to use only one superheater in an interdeck position. Either the interdeck alone or the combination tends to flatten the rating temperature curve. In fact, the interdeck superheater has temperature characteristics quite similar to those resulting from the usual installation of a combination of convection and radiant superheater surface. The interdeck type generally requires more space, which in many instances, is more than offset by the greater cost of the combination superheater. In the radiant superheater the variation in pressure drop and velocity over the load range interposes serious design difficulties for boilers of high capacity, making operation at low steam output hazardous to the life of the tubes.

Radiant type superheaters have been installed behind the side walls of the two 14,500-sq. ft. boilers of the Nashville Railway and Light Co. station. With superheaters designed for high temperatures, it is desirable to employ large headers with single inlet and outlet connections. By this means it is possible to confine the greater part of the pressure drop to the elements themselves and thus secure better steam distribution than where a large proportion of the pressure drop occurs in the steam headers.

Higher Steam Temperatures Anticipated

Ratio of superheating surface to boiler heating surface ranges in the table from 5.19 to 99 per cent, with an average of 24 per cent. Total temperatures of from 700 to 750 deg. F. are common among the large plants and higher temperatures may be anticipated with confidence. Continuous operation of superheaters equipped with ordinary steel superheater tubes has experienced no serious difficulty in producing steam at a temperature of 850 deg. F.

Alloy steels for tubes, shells and castings are now available for more difficult operating conditions than

have heretofore been tried out in practice. Boiler companies state their readiness to guarantee service up to 900 deg. F. Alloy steels for this purpose, when used in the construction of light elements in installations where extremely high heat transfer rates prevail, appear to be of commercial merit. Their use in radiant heat superheater elements seems particularly desirable.

Superheaters installed at the plant of the Solvay Process Co. designed to superheat 120,000 lb. of steam per hour to a final temperature of 735 deg. F. at a pressure of 804 lb. are provided with special header construction. The headers having been forged from a solid billet were bored eccentrically, the heavier side being used for the tube connections. Application of superheaters to power plants of the industrial type is increasing in favor even where process steam is employed.

Steam Velocity Now an Important Factor

One of the serious problems to be solved in connection with the operation of boilers at high rating is the matter of pressure drop through the superheater and the inter-related question of steam velocity. At the high rating the velocity is limited by the drop and this in turn involves a condition of low velocity at low rating.

In installations where the temperatures involved are comparatively low, the steam velocity was of importance only as far as heat transmission was concerned and had little effect on superheater maintenance. With the effort to secure higher steam temperatures, however, there is a tendency to place the superheater nearer the furnace, thus exposing superheater elements to extremely high temperatures. Any reduction of steam velocity below certain limits, whether due to uneven distribution or other causes, is likely to result in the failure of superheater elements.

Low limit of steam velocity has been placed by one manufacturer at 1500 to 2000 ft. per min. based upon the assumption of equal steam distribution. In the case of superheaters located in comparatively cool regions, such as at the top of the first pass, there is little danger of failure of the elements due to low steam velocities, as the cooling effect of the adjacent boiler tubes affords sufficient protection.

Water Flows Upward in Steaming Type Economizer

Limitations imposed by the conventional form of economizer have led to the introduction of the steaming type. This type is arranged so as to permit the water to flow upward; the economizer therefore must be located below the boiler water level. Such a combination affords compact boiler and economizer surface, avoiding some of the limitations ordinarily encountered in designs in which the conventional type of economizer is employed.

It sometimes happens that induced draft fan capacity limits the boiler steaming capacity. To overcome this, arrangements are now employed to bypass part of the gases around the economizer, which not only prevents the formation of steam therein, but also reduces the draft drop, thereby increasing the boiler capacity at the expense of economy. Since the induced draft fan will have to handle gases of higher temperature and corresponding higher specific volume and since the amount of gas will be still further increased by the drop in efficiency, the increase in capacity is somewhat limited.

Air-Water Economizer Has Special Field

Philo station installed an air-water economizer which type was brought out during the past year. This type was designed for use in plants where the full degree of preheat obtainable from such preheaters as may be installed is not required or desired in all parts of the combustion system.

Where these air-water economizers are used, all of the combustion air is heated in the preheater and that portion which is not required at the maximum preheat temperature is passed from the main air duct over the air-water economizer.

At the Hudson Ave. station, the counterflow system is employed. The upper half of the economizer is arranged for counterflow of gas and water and the bottom half is arranged for parallel flow. The discharge water from the upper half is brought into the bottom of the lower half and flows upward. This arrangement was selected by the maker to minimize the likelihood, at low rating, of steam forming in the economizer and working its way to the top, causing water hammer. A careful check of the sacrifice in efficiency due to half of the surface being parallel flow instead of counterflow showed a decrease of only 1/20 per cent.

Extensive use of the regenerative cycle reduces the need of economizers, hence we find, on consulting the table, a number of plants in which economizers are not used. Operation at high ratings has effected this tendency since, while the use of an economizer boosts efficiency at low ratings, the use of air preheaters boosts it at high ratings. In combination, they tend to flatten the economy curve. In considering the advisability of installing an economizer, as in consideration of all other auxiliaries, the decision must be based upon the relation of these auxiliaries to the boiler they are to serve. This is especially true in this day of high ratings.

Before the introduction of the preheater, the final temperature of feedwater was limited to about 212 deg., a higher temperature increasing the temperature of the flue gases unduly and the lower temperature increasing corrosion difficulties. Present tendency is toward increase of feed temperature. This is shown in the temperature of 320 deg. used at Cahokia and of 420 deg. at the Edgar station.

Plate and plain tube economizers continue to be the most popular, due to their simplicity and lack of mechanical parts. Proportion of economizer surface to boiler heating surface ranges from 21.6 to 143 and the preferred location of economizer seems to be back of the boiler; a few are reported as located above the boiler. An intertube superheater which is an adaptation of the multiple loop single pass superheater has recently been introduced. Higher temperatures of discharge water and inlet gas are reported, the former being as high as 469 deg. F., while the latter is as high as 612 deg. F. All temperatures reported are high.

Production of electric power by public utility power plants in the U. S. for September, 1928, reached a total of 7,269,888,000 kw-hr., according to a recent report of the Geological Survey Department of the Interior.

Feedwater Treatment and Heating

COMBINATION METHODS ESPECIALLY OF EVAPORATION WITH OTHER TYPES CHARACTERIZE PRESENT TREATMENT TENDENCIES

SEVERE CONDITIONS imposed upon water screens and water tubes of boilers operated under the increasingly high ratings now being employed requires more thorough boiler feedwater treatment than formerly. Operating experience with high pressure boilers has shown a considerably greater tendency toward scaling but proper treatment of feedwater has corrected scale troubles resulting from condenser leakage. Boiler tube failure occur with considerably less scale present and are due primarily to the increased stresses caused by the higher temperatures and pressures. Failures without scale formation are unknown.

DEVELOPMENTS IN EXTENSION AND PERFECTION

While no outstanding developments in methods of water treatment have been brought out during the past year, boiler feedwater control has been characterized by a wider use of water treatment methods, by a more thorough application of treatment methods based upon individual conditions and by a combination of different elemental processes such as that of evaporators with a zeolite process in order to remove elements accumulated in the water due to concentration.

Consulting the table we find many different systems of water treatment were reported, most of the plants have adopted combinations of several methods of treatment. This indicates the necessity of careful analysis of individual conditions, and follows obviously because of the greatly varying conditions and compositions of the raw waters from which these plants draw their feeds.

Increased use of evaporators, especially in combination with other processes of treatment, will be noted. This indicates that distilled water for make-up is becoming an important method of feedwater treatment and that although some operating difficulties are being encountered with certain raw waters, the general high quality of the distillate and low net cost of installation and operation of evaporators warrant their consideration for all large installations. Operation reports indicate that evaporator outputs are being kept at a high degree of purity over extended periods of service and with various grades of water.

Manufacturers of evaporators point out that it is erroneous to assume that the evaporation of softened or treated water at high temperature produces steam which is chemically pure. In all raw feedwaters, magnesium compounds are present and with the exception of the carbonate, they are not precipitated. At temperatures just above 212 deg. F. the chloride is decomposed into hydrochloric acid and magnesia and the acids are pres-

FEEDWATER TREATMENT & HEATING

NAME OF STATION	TREATMENT					HEATING			STAGE HEATING										OTHER HEAT RECOVERY
	SOURCE OF WATER	SYSTEM	BLOWDOWN PERIODS	BLOWDOWN % TOTAL FEED	LIMIT OF CONCENT. GR/GAL.	SOURCE OF HEAT	TYPE HEATER	FINAL F.W. TEMP.	FIRST TEMP.	FIRST PRES.	SECOND TEMP.	SECOND PRES.	THIRD TEMP.	THIRD PRES	FOURTH TEMP.	FOURTH PRES.	FIFTH TEMP.	FIFTH PRES.	
PHILO 1928 EXTENSION	RIVER	LIME-SODA	DETERMINED BY CONCENTRATION		100	EXTRACTION	CLOSED	320	90	5.4	180	21	215	53	283	100			EVAPORATOR, AIR JETS - GEN. AIR COOLERS
CAHOKIA 3RD SECTION	MISS. RIVER	HYDRATE LIME IRON SULPHATE BARIUM HYDRATE	36 HR	0.7	3.75 CHLORINE	"	"	330	181	0.9	250	30.9	301	76	347	142.8			EVAP - OIL COOLER - GEN. AIR COOLER
VIENNA, MO. STATION	WELLS	SPECIAL SUPERVISION DAILY ANALYSIS	8 "	2		"	CLOSED + DIR. CONT. DEAER.	220	153	5	215 250	15 30 ABS							
LONG BEACH NO. 3	WELLS	ZEOLITE BEFORE EVAP. TO ELIMINATE SCALE	INFREQUENT DEPENDING ON COND. LEAKAGE		60	"	CLOSED	385	177	76	272	36	440	100	605	229			
KEARNY 1928 EXT.	CITY MAIN	TRI-SODIUM PHOSPHATE CAUSTIC SODA SODIUM SULPHATE	NOT YET IN SERVICE			"	1-OPEN 3-CLOSED EA. UNIT	325	150	6 ABS	213	16 ABS	260	36 ABS	325	113 ABS			
BINGHAMTON 1928 EXT.	RIVER	PERMUTIT EVAPORATOR	CONTINUOUS WHEN REQUIRED		CONSTICITY 50	EXT. + SMALL AUX TURB.	CLOSED	212	168	4.7	235	22.8							EVAPORATOR DEAERATING HEATER
HELL GATE 1928 EXT.	CITY MAIN	HALL	AS REQUIRED BY ANALYSIS			EXTRACTION	"	212	† 140 * 172	4.2 7.8	207 210	15.3 17.2							EJECTOR
SAGINAW R. 1928 EXT.	RIVER	MAKE-UP EVAPORATED				"	"	AV 200 FULL LOAD 29" VAC 220	HOT WELL 79		FROM INTERCOOLER 81		TO EVAP	54.6	L P HEATER 156	51.2 ABS	I.P HEATER 220	19.5 ABS	
STATION C P.G.+E. CO. 1928 EXT.	WELLS CITY MAIN	HOT LIME + SODA EVAPORATOR				STA. AUX. FOR SOFTENER EXT. FOR EVAP.	OPEN FOR SOFTENER	210	165	6	223	20	282	57	362	172			EVAP
HORSESHOE LAKE 1928 EXT.	RIVER					AUXILIARIES	OPEN	212	150	44 ABS	281	76 7 ABS							EVAP - GEN. AIR COOLERS RADIJET
EDGAR 1928 EXT.	CITY MAIN	SODIUM PHOSPHATE			80	EXTRACTION	2-CLOSED 1-OPEN	420	199	37	250	33.4	290	63.5					EVAP - OIL + AIR COOLERS - ECON - VENT COND
HUDSON AV. 1928 EXT.	CITY MAIN		DEPEND'S UPON CONCENTRATION	0.8	100	EXT ECON.	CLOSED	268 380	203	19.45 ABS	271	19.7 ABS							EVACTOR GEN. AIR COOLER
GOULD ST.	CITY MAIN								10 7TH 182		AFTER COND. 209		8 TH 247		EVAP COND 234		5TH 316 3RD 365		EVAP. GEN. AIR COOLER.
TORONTO 1928 EXT.	RIVER	COAGULATION SEDIMENTATION EVAP. EXTERNAL			25	EXT	CLOSED DEAER	372	81 194	9.14 ABS	GLAND STM COND AND DEAER 194 - 210 15 ABS.		210 - 260	43 ABS	206 - 305	89 ABS	305 350	195 ABS	EVAP
TRINIDAD	LAKE	PERMUTIT AND EVAPORATOR	2 WKS	0.05	29.2	"	CLOSED	345	3RD STAGE 345	196 ABS.	7TH STG 247	39 ABS	11TH STG 157	55 ABS					EVAP - GLAND STM LEAKOFF OIL-GEN AIRCOOLER
CRAWFORD 1928 EXT.	CANAL	PERMUTIT				"	CLOSED												
LAKE PAULINE	LAKE	INTERNATIONAL CRYSTALLITE	8 HR	2		"	3 CLOSED 1-DEAER	325	1ST STG 325	17 ABS.	4TH STG 285	53 ABS	6TH STG 225	19 ABS	11TH STG 155	5 ABS			EVAP COND. DRAIN HEAT EXCHANGER
U. S. RUBBER CO.	LAKE	LIME SODA ASH SODIUM ALUMINATE	8 "	3		" EXHAUST	OPEN	210 *											
ACHESON HARDEN	CITY MAIN	ZEOLITE	24 "	0.7	0.5° BAUME	"	"	208											STEAM HEATING SYSTEM
PISTON RING CO.	WELL	ZEOLITE SOFTENER DEAERATOR	12 "	3		"	"	225											
ANGLO-CANADIAN	RIVER	DI SODIUM PHOSPHATE	BLR. 6 HR. W.W. 4 "	2	60 TO 80	TURB. EXH.	CLOSED	263	60	25									
SORG PAPER CO.	WELLS	LIME BARIUM CARBONATE	24 "			AUX. EXHAUST	OPEN	235											EVAP
STANOLIND	LAKE	ZEOLITE + ACID	CONTINUOUS	6	195	L. P. TURB. EXHAUST	DEAER.	200											HEAT EXCHANGERS IN BLOWDOWN SYSTEM

† - AT 100,000 KW. LOAD * - AT 160,000 KW. LOAD

ent both in the liquid and gaseous state. Many severe cases of corrosion have been traced to this cause.

Chemical Treatment Precedes Evaporation

Cases in which priming, reduced capacity and extended outages for cleaning have been reported, however, and with some grades of raw water, chemical treatment ahead of the evaporators has been found to be an economical procedure in the light of the higher capacities and reduced outages for cleaning. In these

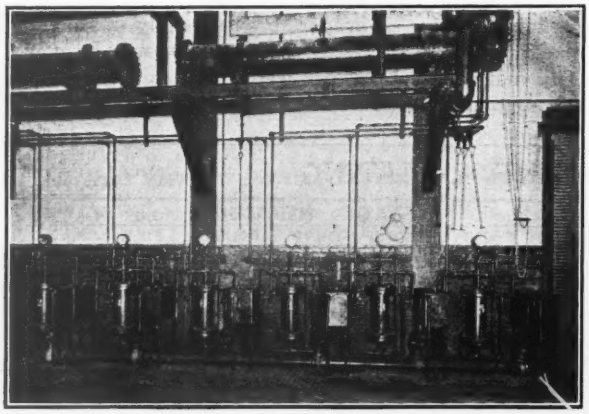


FIG. 1. NON-FLASH TYPE CONTINUOUS BLOWOFF WITH TWO EXCHANGERS AND INDIVIDUAL STRAINERS AND CONTROL BOXES AS INSTALLED ON A BATTERY OF SIX BOILERS

cases the water treatment and the problems involved are similar to those for treatment of water delivered to boilers direct. These operating difficulties indicate that improvements in design are desired especially with reference to ease and quickness of cleaning.

Heat for evaporators is derived from live, exhaust and bled steam and the evaporator plant is usually introduced as a step in the station heat balance. Single installations are found in which there are four effects. Study of the heat balances of different plants considered in our analysis as given elsewhere in this issue will show in each case the effect of the addition of an evaporator on station performance. Even with the use of evaporators, chemical treatment may be needed under present high pressure boiler operation due to contamination caused by condenser leakage.

Evaporators Used to Reduce Concentration

Installation of evaporators at the Crawford Avenue Station was for the purpose of reducing boiler water concentration. Pretreatment of the raw water make-up was by the Zeolite process which resulted in a high sodium content in the boiler water. Under the high pressure and temperature conditions prevailing at this station, numerous troubles were experienced due to carrying over solid matter into the prime movers, fouling screens, blades and nozzles. Two of the plants listed, Long Beach and Trinidad, adopted this system of using an evaporator after Zeolite treatment in order to remove concentrate.

At the former plant, the evaporators were formerly cleaned once a month by chipping the scale off the tubes by hand. This cost $100 per evaporator per month and involved a loss of 1½ days operation. A weak solution of hydrochloric acid was later used at a cost of $78 a month and involving 8 hr. in time. Another method of cleaning scale from evaporators is by cracking it by rapid temperature changes. The cracking-off method is effective only when the scale is hard and brittle but this type of scale is not at all universal. In most installations the scale is not easily cracked and hand cleaning, which requires much labor and time may be necessary. Moreover, rapid temperature changes increase the wear and tear on the coils which are costly to replace.

In the Long Beach plant, scrubbers are used also to remove moisture and solids from the vapor and at this station the zeolite was regenerated and back-washed about every 60,000 gal. At the Beacon Street heating plant, the treatment system involved the removal of CO_2 from Zeolite-treated water by means of sulphuric acid.

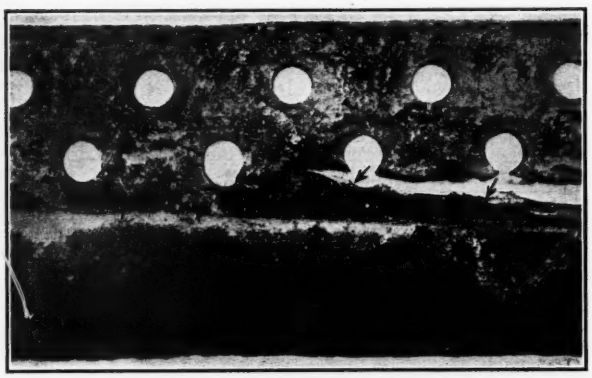


FIG. 2. SECTION OF RUPTURED BOILER PLATE WHICH FAILED DUE TO EMBRITTLEMENT

The addition of acid served to liberate an equivalent amount of CO_2 which, passing through a deaerator before going to the boiler, resulted in removing the free CO_2 along with the oxygen.

Hell Gate Station removes precipitated and suspended solids by a continuous circulation of the boiler water, forced by a centrifugal pump, from the mud drum through a deconcentrator filter bed and back to the main drum of the boiler. The solids caught by the filter, are removed daily by backwashing, and discharged into the sewer.

More Discharge by Continuous Blow-Down

Blow-down periods followed in the plants listed, vary from 4 hr. to 2 wk. Continuous blow-down being employed in only two of the plants. Less than half of the plants investigated reported the percentage of total feed that was blown down but of those that did report the range was from 0.05 to 6, the latter being that of one of the two plants employing continuous blow-down.

Several operators reported that their period lengths were determined by analysis of the water, indicating that tests and records are playing more and more important parts in plant operation. Less than half also, reported concentration limits they allow. It is believed that the importance of knowledge of the degree of concentration is sufficiently great to cause all plants in the future to know this definitely at all times so that provision for elimination of concentrate may be made.

Frequency of blowoff is increased by the fact that the foaming limit of concentration decreases as the rate of evaporation increases per square foot of heating surface and per square foot of steam engaging surface. Frequency of blowoff, due to the labor of manipulating the blowoff valves so often as well as to the heat loss in the blowoff water, has naturally created a demand for automatic continuous boiler blowoff apparatus with heat recovery, but other elements already mentioned have entered into consideration as indicated in the table. Continuous blow-down is especially applicable where solids concentrate rapidly and where there is a marked tendency toward priming and foaming.

Continuous Sludge Removal Reduces Hardness

One treatment system now being employed uses external chemical treatment for softening the water and eliminates mechanical impurities before the feedwater enters the boiler and then stabilizes the composition of the water in the boiler by continuous removal of the residual hardness and of the soluble salts. In this system soda ash is added in a settling tank and the bicarbonates are decomposed by heat into insoluble carbonates and CO_2, the latter being driven off with the air at a temperature of 200 deg. F. The precipitates are separated from the clear softened water by sedimentation. Continuous sludge removal keeps down the residual hardness and the sludge is precipitated in the settling tank. The heat of the return boiler water and the soda contained in it are utilized in the softener for the treatment of additional crude water through the use of a stabilizer.

Extraction steam as a source of heat for feedwater continues to hold first place in choice while exhaust steam, coming mainly from station auxiliaries, represents a secondary choice of source of heat as represented in the plants listed. The majority of the heaters used are of the closed type, only 40 per cent being of the open type. This approximately follows the proportion found in last year's analysis. Feedwater is being maintained at increasingly higher temperatures. The Edgar station maintains a final feedwater temperature of 420 deg. while eight other plants report temperatures over 300 deg. Automatic control of feedwater is now almost universal in large power stations.

Equipment Arrangement Determines Method

Feed heating is accomplished at the Hudson Avenue Station by means of two stages of turbine extraction. Two stages were selected because of the use of economizers in the boiler house and also to simplify the turbine room basement. In consideration of the boiler house and turbine room layout, a careful comparison was made of arrangements of economizers and two stage feedwater heating vs. air preheaters and four stage heating. Experience had been gained on the fourth unit in the station with preheated air and while no handicaps faced the repetition of the use of preheated air from the standpoint of using preheated air in conjunction with stokers, there were definite objections to its use on account of layout difficulties. The original building design of this station did not contemplate installation of air preheaters, therefore adequate space was not available and undesirable congestion would have resulted.

This condition, together with difficulties attendant on dampering shutting down fans and shutting down boilers from the group duct and general heat conditions due to extensive hot air duct areas, influenced heavily against duplication of the preheated air layout. Carefully prepared investment and operating cost analysis showed a slight capitalized saving in favor of installing air preheaters, but it was judged that the handicaps against the necessary air preheater layout were sufficient to overbalance the preference for preheated air shown in the comparison of tangible items. As the design with economizers actually materialized, it transpired that somewhat greater boiler house capacity was secured than in the case of the preceding preheated air installation and this with a much simplified layout.

Stage Heating and Heat Recovery Increasing

Most of the central stations investigated use at least four stages of heating, three of them reporting five stages. All stage heaters and air ejection equipment in the Long Beach Station is located so that it may be controlled from the turbine platform. Of the other methods of heat recovery employed, the use of an evaporator has led all others. Half of the plants investigated employ evaporators. Six recover the heat obtained from their electric generators.

Corrosion and embrittlement of boiler materials and the condition of feedwater which cause them were studied more intensively than before and much valuable data have been obtained concerning the control of destructive ingredients and conditions. Maintenance of definite alkalinity and the elimination of CO_2 and oxygen have been found to be essential but since CO_2 is far less destructive in the absence of oxygen, the elimination of oxygen has been given primary consideration.

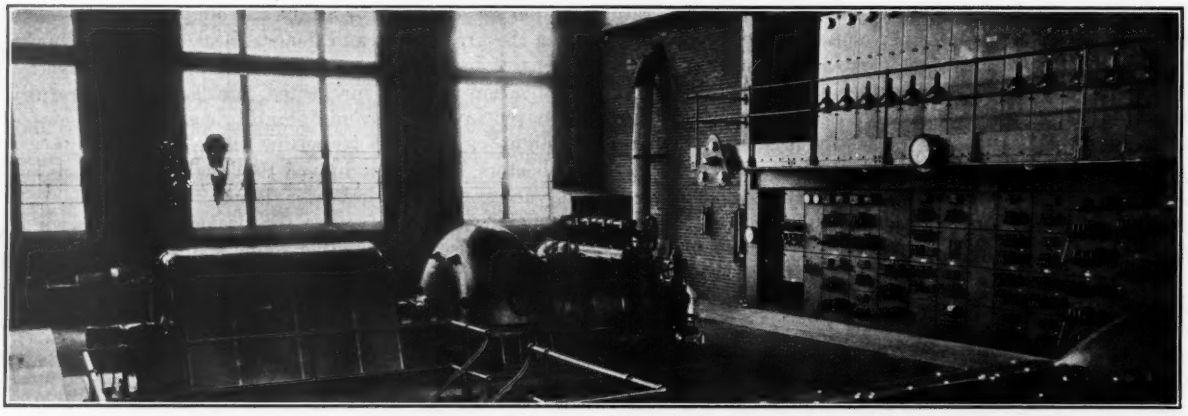
Corrosion and Embrittlement Prevention

Prevention of corrosion troubles have been effected by decrease of the oxygen content of the feedwater to 0.45 c.c. per liter and maintenance of a positive caustic alkalinity. At the Milwaukee Electric Railway & Light Co. station it was found that the maintenance of an oxygen content below 0.1 c.c. per liter could be attained without the use of a deaerator.

Investigation of ten cases of embrittlement by Professor Straub at the University of Illinois, showed that in all instances the boiler feedwater did not meet the A. S. M. E. recommendation as to the sodium carbonate —sodium sulphate ratio. The sulphates were low in all cases. Recent thorough examination of boilers at the University that had formerly given trouble, revealed the fact that a lime treatment followed by addition of sufficient sulphuric acid to neutralize about two-thirds of the sodium carbonate in the water resulted in freedom from all indications of embrittlement after 10 yr. of operation on this treated water.

Electrolytic methods are now also being applied to the problem of preventing corrosion but none of the stations investigated had yet applied this method, however electrolytic methods give promise of prominent commercial application in the near future.

Growing recourse to testing methods as a guide to adequate control of quality of boiler feedwater, which may be expected to develop much more completely in the future, has led to the production of a handy portable water testing outfit.



New Developments in Turbine Room Practice

PRACTICAL DEMONSTRATION OF THE VALUE OF HIGHER PRESSURES, REHEAT AND MERCURY VAPOR CYCLE TOGETHER WITH IMPROVED EQUIPMENT MARKS YEAR'S PROGRESS. BY JAMES A. POWELL*

DEVELOPMENT in turbine room practice during the year 1928 has been notable along the lines of betterment in both efficiency and design. Increase in efficiency is due principally to the use of turbines and auxiliary equipment for higher steam pressures and temperatures rather than in improvement or refinement in detail design. Refinement in design is responsible for greater reliability in equipment and units of increasing size. Consequently it also tends to increase efficiency.

Equipment for a steam temperature of 750 deg. F. is being used and its use can be justified. Still higher temperatures are being considered but, with the present development of metals and materials for handling high temperatures, it appears that for the present we should be content with maximum temperatures of 750 deg. F.

Reheating of steam between turbine units has passed through the experimental stage and can be justified with pressures of 550 lb. gage and higher. Reheater designs are governed by the same limitations as superheater design, and are therefore limited to a maximum temperature of 750 deg. F.

There are five stations at the present time operating at pressures from 550 to 650 lb. gage, several stations are operating or being designed for 800 to 900 lb. gage, and five stations are being designed or are operating at 1200 lb. gage steam pressure or above.

HIGH-PRESSURES EFFICIENT AT LIGHT LOADS

Equipment for steam pressures up to 1400 lb. gage has passed the experimental stage and, while there remains considerable development work to be done, plants for the higher steam pressures can be constructed from the ground up rather than by experimentation in existing high-pressure stations.

When stations using reheated steam between turbine units were first considered, it was generally thought that they could be justified only in cases where the station would operate at high load factor. This same thought prevailed in regard to stations employing the higher steam pressures. On the contrary, however, reheat stations are more efficient under light load operation than the nonheat stations. This is due to the additional reheat in the steam at light loads which offsets the loss in turbine efficiency.

At first, 1200 lb. steam pressure stations were considered as an increment to existing rather efficient stations, thus allowing the high-pressure unit to be operated upon base load conditions; however, new plants which are added to the average power system must be able to operate efficiently through the peaks and valleys of the system load. In the average system, especially those having hydro stations, the condition of base load might apply to the new station for the first year or two after it goes into service, depending more or less upon the water available for the hydro stations but any additions of more economical equipment to the system usually reduces the existing units to a condition of variable load operation.

GOVERNING OF NEW 1200-LB. CROSS COMPOUND UNITS DONE AT HIGH-PRESSURE ELEMENT

Design of the 1200-lb. installations which are in operation to date have been based on using 1200-lb. noncondensing turbines, exhausting through reheaters into fixed pressure headers which supply steam to lower-pressure turbines already installed. This arrangement was satisfactory when the high-pressure steam available from the high-pressure unit was small in comparison with the total steam required in the station, for then the high-pressure unit could be run on base load conditions most of the time.

Where the station is to have high-pressure steam only and an average load factor, however, there is no reason for maintaining a constant header pressure between the high and low-pressure turbines. Not only are complicated governing problems involved but there is also a decided loss in efficiency due to governing on two separate units operating in series. Consequently the better arrangement for a 1200-lb. station is a cross

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compound unit, the governing being done on the high-pressure unit only, allowing the cross over pressure, which is the reheat pressure, to fluctuate up and down depending on the load.

Turbine designers have given a great deal of study to the development of a high-pressure unit which would be satisfactory for variable load and have designed a unit which has five governing valves instead of the single governing valve common to the high-pressure units now in service. This multiple governing valve arrangement makes possible a flat heat consumption rate through a wide range of load due not only to the multiple valve arrangement but to the added reheat advantage as well. The idea of multiple governing valves is also being used by turbine designers for low-pressure units where light load economy is desirable.

Low First Cost Dominates Standby Station Design

On the other hand, where turbines are to be used as standby units for hydroelectric systems, it has been found that economics may favor a single valve machine due to the lower first cost. For the same reason, where standby units for hydroelectric systems are considered, units which are capable of carrying large overloads although suffering a reduction in economy due to low vacuum and other causes, have been found to be most economical.

At the present time, turbines have been built up to 75,000-kw. capacity in a single shell at both 1500 and 1800 r.p.m. and up to 160,000-kw. capacity on a single shaft. Turbines of larger kw. capacity are being built but are of the cross compound type.

An interesting and economical installation for the generation of steam for industrial purposes is in the process of design. It consists of a 1200-lb. pressure turbine exhausting into evaporators. Raw water is fed to the evaporators and converted into steam for industrial use, while the condensed steam from the evaporators is returned to the high-pressure boilers.

Starting and shutting down large turbine units without deformation of the turbine spindles has had considerable study and investigation by operating companies and manufacturers.

Mercury Cycle Offers Increased Efficiencies

A 10,000-kw. mercury cycle turbine and boiler has been installed but to date no operating data is available. The mercury cycle theoretically offers a more economical plant for the production of low-pressure steam than the use of 1200 lb. steam pressure but more experience is necessary before it can be proven economically sound.

Single-pass condensers are being more generally used and with them smaller tube sizes are being employed. In the past, turbines have been equipped with too large condensers and there seems to be a decided tendency towards the reduction in condenser surface per unit of turbine capacity, or, a better way of expressing it would be, an increased quantity of steam condensed per hour per square foot of condenser surface.

With the use of water-cooled furnace walls in connection with boiler units, every effort is being made to keep the condensate, which becomes the boiler feedwater, free from impurities; with this in mind, it has been found desirable to roll condenser tubes into the tube plates at both ends, thereby eliminating packing and ferrules which are subject to leakage. The lineal expansion of the tubes is compensated for by either allowing the tubes to bow or by providing floating tube sheets or floating water boxes.

Air ejectors continue to be the most used air removal apparatus. In the 1200 lb. pressure stations, where motor-driven auxiliaries are used almost entirely, a motor-operated vacuum pump is used for the second stage in connection with a first stage steam jet which uses gland steam for its motive power.

More Attention Being Paid to Auxiliaries

Where condensate pumps take condensate from the condenser hot-well and discharge it through closed extraction heaters operating on variable load, there has been experienced considerable trouble with erosion of pump impellers due to cavitation. This difficulty has been overcome by the use of a constant pressure regulator in the discharge line of the condensate pump.

Use of air preheaters in connection with boiler units has had a large bearing on the number of extraction heaters used. With steam pressures up to 400 lb. and the use of economizers for final heating surface in the boiler unit, two extraction heaters seem to give the best and most economical results but where an air heater is used for final surface in the boiler units, three stages of extraction heaters are desirable.

With steam pressures of 550 lb. and higher, where higher temperatures in the boiler are encountered, air heaters are necessary for final boiler unit surface in order to have an efficient steam generating unit. In this case, three extraction heaters should be employed and generally the fourth can be justified.

Deaerator Now Used in Most Stations

There seems to be a diversified opinion regarding the use of drip pumps for removing condensate from extraction heaters as against the method of cascading the condensate from each heater back to the next lowest pressure heater. Cascading the condensate back through drainers offers a simple arrangement but the reliability of this method is questioned by many engineers. The use of drip pumps results in a more expensive arrangement but this method gives a higher efficiency and is somewhat more reliable than the drainer method. A combination of the two methods is generally found to give the best arrangement. In the 1200-lb. plants, the extraction heaters are interposed between boiler feed pumps on the water side and with this arrangement it is necessary to design them for a water working pressure of approximately only 600 lb.

Preference in extraction heaters seems to be for the closed type in all cases except the deaerator. Deaerating heaters are constructed in both the closed and open type, and each type is about equally favored and used. Since the advent of the higher steam pressures, higher boiler ratings, and water-cooled furnaces, deaerating heaters are a standard piece of equipment in the modern station.

Evaporators are usually found in stations operating high rating boilers and water-cooled furnaces. They are generally connected in parallel with one of the extraction heaters but when added to an existing station they sometimes take the place of one of the extraction heaters.

Heat Balance Tends Toward Increased Extraction

NEW STATIONS USE LARGER PERCENTAGE OF BLED STEAM. USE OF EVAPORATORS ALMOST UNIVERSAL. INCREASED ATTENTION BEING GIVEN TO DEAERATION OF FEEDWATER. MANY PLANTS USE BOTH ECONOMIZER AND AIR HEATER

DURING THE PAST YEAR, no radical change or improvement has been made in the heat balance of the modern power station. There is, however, a decided trend toward the utilization of a larger percentage of bled steam, some stations using over 25 per cent of the total flow of steam to the turbine. For instance, Philo bleeds 28.8 per cent while Cahokia, Long Beach, Station C, Edgar and Gould Street all use close to 25 per cent.

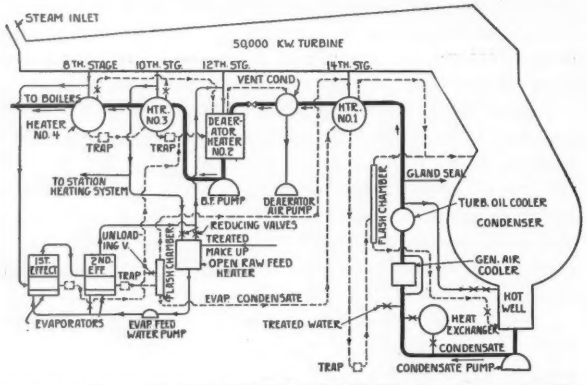


FIG. 1. AT CAHOKIA STATION UNIT NO. 5 IS THE FIRST OF TWO UNITS FOR SECTION 3

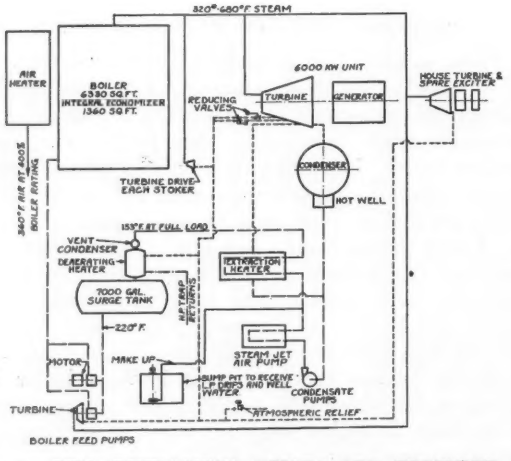


FIG. 2. TWO EXTRACTION POINTS ARE PROVIDED ON THE 6000-KW. TURBINE AT VIENNA STATION

At Philo, the air water economizer used allows higher entering feedwater temperatures to be used without danger of corrosion as the flue gases do not come in contact with the economizer. By using air preheaters following the economizer, many stations are getting away from the limit of 200 to 210 deg. F. formerly considered good practice with ordinary economizers.

Reference to the air heater and economizer tables shows several stations using temperatures to the economizer in excess of 210 deg. F. among them Edgar, where the exhaust of the 1200-lb. turbines will be used for the last or high pressure closed heaters. Practically all stations, both central station and the larger industrials, are using air heaters, the majority designed to reduce the flue gas temperatures to about 350 deg. F. Some, however, go as low as 240 and as high as 484, depending upon local conditions and the fuel used.

Evaporators are coming into more general use as boiler pressures and ratings are gradually increased. Perhaps the most interesting development in this line is the use of treated or softened water for evaporator feed in order to avoid excessive scale and corrosion in the evaporator. Condenser leakage is becoming of increased importance as is the necessity for careful evaporator operation in order to prevent excessive carry over. For these two reasons, the use of evaporators does not always completely eliminate the necessity for chemical treatment of the feedwater.

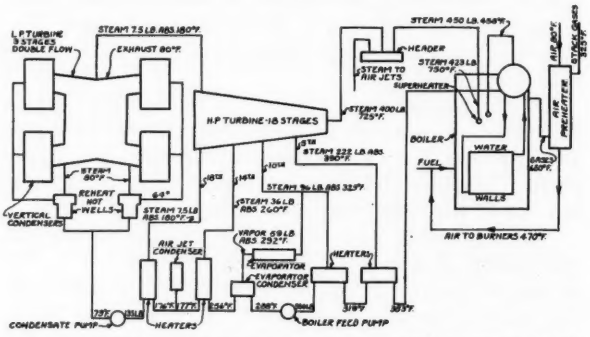


FIG. 3. AT LONG BEACH NO. 3, A PERFORMANCE OF 14,000 B.T.U. PER KW-HR. IS EXPECTED

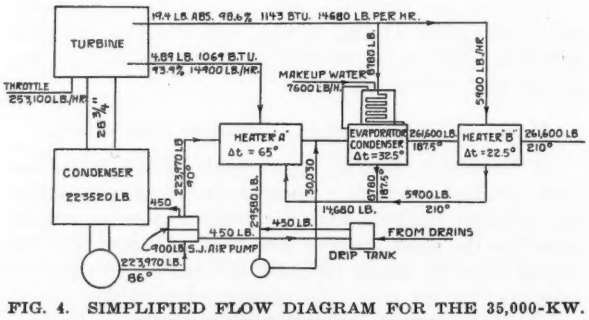


FIG. 4. SIMPLIFIED FLOW DIAGRAM FOR THE 35,000-KW. UNIT AT BINGHAMTON STATION

Beach, Station C, Edgar and Gould Street all use close to 25 per cent.

There is a definite limit to the amount of steam that can be utilized for feedwater heating, evaporating and deaerating, this limit being determined by the water rate of the turbine, the makeup necessary, the maximum feed temperature and the extent to which other heat sources, such as generator air cooler, oil cooler and steam jet pumps, are used.

less than ½ of one per cent makeup, although the capacity of the equipment will be such as to furnish 2½ per cent in an emergency. State Line, where the steam flow to the condenser will be about 1,600,000 lb. an hour, will have an evaporator capacity of but 80,000 lb. an hour, or between 0.3 and 0.5 per cent of the flow to the turbine. These evaporators will operate as two single effect units of two evaporators each. Each evaporator has a surface of 800 sq. ft. and each pair will vaporize 40,000 lb. of raw water an hour, using 46,500 lb. of 43 lb. abs. steam superheated to 60 deg. F. Two 3900-sq. ft. evaporator condensers of the floating head two

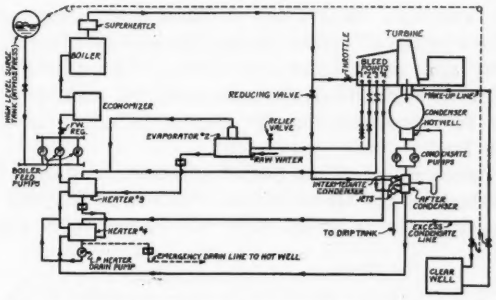


FIG. 5. AT SAGINAW RIVER STATION, UNIT NO. 3 HAS A CAPACITY OF 30,000 KW.

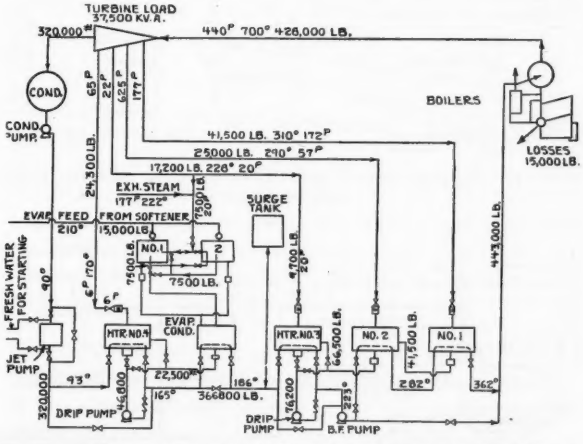


FIG. 6. STATION C AT OAKLAND HAS THE LARGEST 9-STAGE TURBINE EVER BUILT

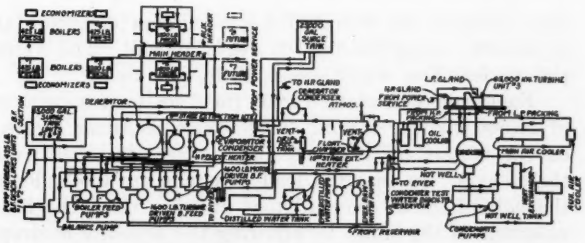


FIG. 8. FLOW DIAGRAM OF THE 450 AND 1200-LB. SYSTEM AT EDGAR STATION

pass type are designed to be supplied with 1,100,000 lb. of 178 deg. condensate per hour.

Corrosion and the necessity for reducing the oxygen content of the feedwater to a minimum have caused some changes in details of the heat balance but have not greatly affected the final result. Open surge tanks are considered sources of free oxygen absorption and are now generally steam blanketed. Free oxygen must be driven off and this can often be done to a satisfactory degree in an open heater if the temperature is kept at

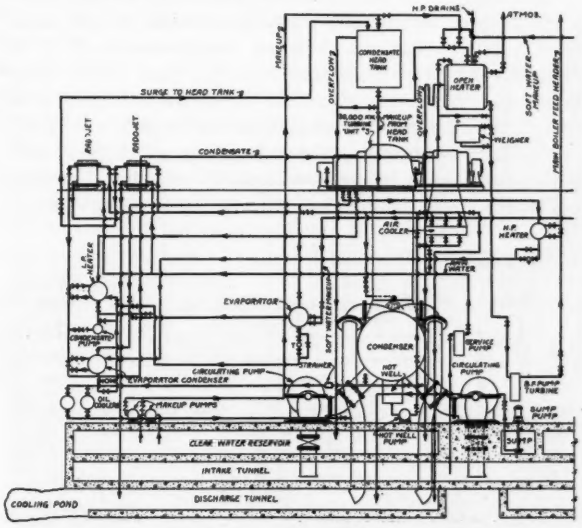


FIG. 7. AT HORSESHOE LAKE STATION, THE 30,000-KW. UNIT NO. 3 IS BLED AT THREE POINTS

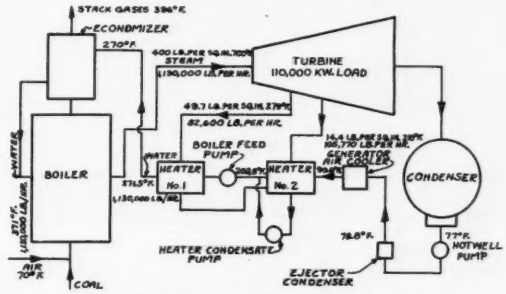


FIG. 9. UNIT NO. 5 AT HUDSON AVENUE STATION IS DESIGNED FOR TWO POINT EXTRACTION

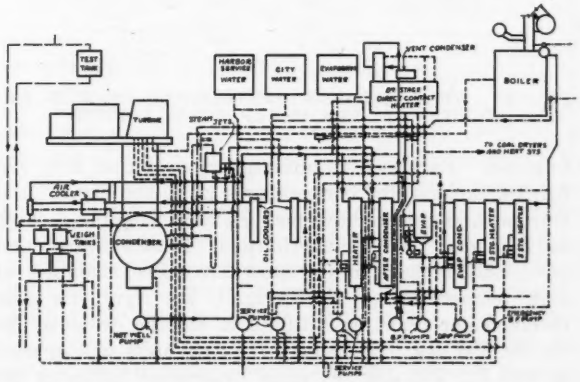


FIG. 10. FLOW DIAGRAM OF GOULD STREET STATION WHERE FOUR-STAGE EXTRACTION IS USED

210 deg. F. or higher. Where temperature variations occur, venting the apparatus to the main condenser has, in some cases, eliminated the necessity for special deaerating equipment.

Makeup may be introduced into the hotwell lines or directly to the main condenser at a temperature higher

than the exhaust temperature. The resulting flashing liberates the gases. Where deaerating equipment is installed, satisfactory operation and performance usually result regardless of the type.

An analysis of high pressure station operation shows a remarkable uniformity between stations of the same type. Reheat stations show an improvement of 12 to 15 per cent over nonreheat stations, part of the gain being due to the use of higher pressures and part of it due to the increased expansion in the superheated field.

In this connection, the advantage of higher temperatures cannot be underestimated and the high temperature installations in Europe are being closely

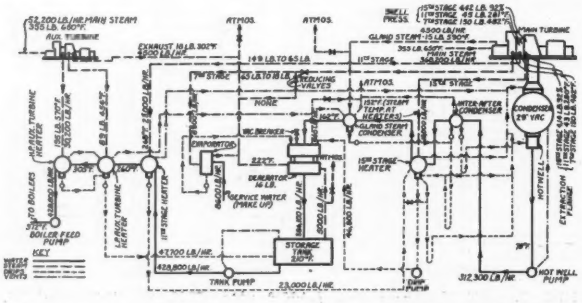


FIG. 11. AN AUXILIARY TURBINE IS USED AT TORONTO STATION TO MAINTAIN A CONSTANT FEEDWATER TEMPERATURE

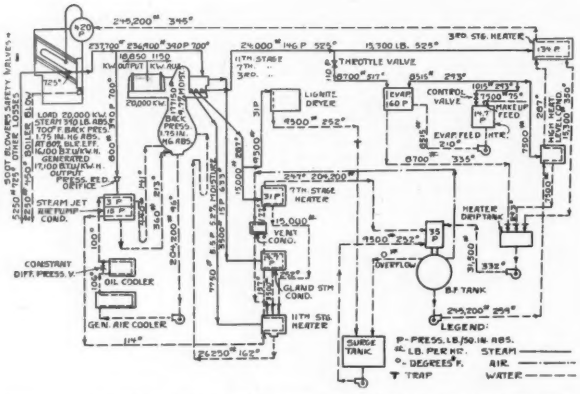


FIG. 12. HEAT BALANCE OF TRINIDAD STATION DESIGNED TO BURN CHEAP TEXAS LIGNITE

followed. European manufacturers state that they can furnish turbines for temperatures up to 900 deg. F. and European engineers have not hesitated in going as high as 850 deg. F. Langerburgge, Rummelsburg and Siemens-Schuckert in Germany are three examples of high temperatures. In England, the Synthetic Ammonia boiler plant at Billingham will be designed for 950 lb. 850 deg. F. although the first units will operate at 600 lb., 700 deg. F. until experience indicates the wisdom of increasing the pressures and temperatures.

From a theoretical standpoint, the gain in efficiency from increasing the temperature from 750 to 850 deg. F. is almost as great as from reheating as it is now practiced, while the cycle is greatly simplified. Pressures and temperatures alone are not, however, the only factors to be considered in efficient station operation. Low stack temperature, high CO_2, low turbine room heat consumption, low exhaust pressure and freedom from large standby losses and uneconomical loading must be considered.

High pressures and extremely efficient heat balances are justified only when good turbine loading can be obtained. Up to this time, advances in power station design have made it advisable to build new plants as base load plants and use the older, less efficient stations for peak load; however, recent developments have not been so rapid and the advisability of building cheap peak load stations is being discussed.

One of the most interesting methods of taking care of the peak load is now being installed in the old Charlottenburg Station in Berlin where 24 accumulators and two 20,000-kw. turbines are being added. Boilers in the old plant charge the accumulators during night and noon hour load drop. The turbines use saturated steam from the accumulators, making a safe, moderate pressure, quickly started plant to carry the peak load.

Another interesting peak load station design is being installed for the Great Indian Peninsular Railway near Bombay. Heavy peak loads will be required and the

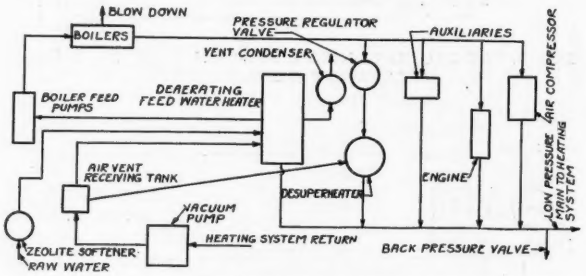


FIG. 13. STEAM FLOW DIAGRAM OF THE PISTON RING CO. PLANT

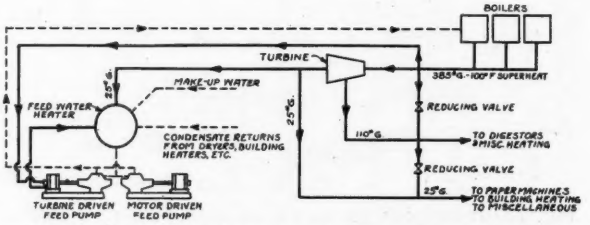


FIG. 14. ANGLO CANADIAN PAPER CO. STEAM FLOW DIAGRAM

four turbines are designed for maximum efficiency at 10,000 kw., using 250 lb., 700 deg. F. steam. The water rate under these conditions is 10 lb. per kw-hr.

Each unit will carry 12,000 for 2 hr. or a maximum of 16,500 kw. for 2 min., these overloads being carried on the boilers by auxiliary oil furnaces installed over the stokers. In case the load demands are too sudden, the boilers act as accumulators drawing upon the heat reservoir of the boiler by allowing the pressure to drop. For this reason, the turbines are designed to develop 16,500 kw. at 190 lb. pressure.

It is probable that further improvements in heat economy will be much slower than they have been in the past few years, that is, more in the nature of refinements to existing practice. Far-sighted engineers are looking with interest at the binary vapor cycle and the new South Meadow Mercury installation will be closely followed after it is put into regular operation.

Record Breaking Turbines Now in Service

100,000-Kw. Machines Looked Upon as Moderate Sized Units. State Line Machine Rated at 208,000 Kw. Will Be in Service Next Summer

JUST AS 1927 was characterized as "the year of anticipation," the year 1928 may well be called "the year of realization"—the year when dreams of turbine units of 100,000 kw. and over came true. Many such units are now in operation, among them the Crawford 104,000-kw., the Hudson Ave. 110,000-kw., the Hell Gate 160,000-Kw. and the Philo 165,000-kw. unit.

While these units hold the center of the stage before those who think primarily in terms of size, they are not by any means the most interesting developments of the year. Edgar, following successes with its first 1200-lb. installation, placed in operation a 10,000-kw., 1200-lb. unit and a 65,000-kw., 450-lb. unit. The 10,000-kw. unit has the distinction of being the largest high-pressure turbine ever constructed, although this will not be true when the 10,000-kw., 1200-lb. unit at Northeast Station is started shortly after the first of the year.

Interest in high pressure was increased greatly by the announcement of a new high-pressure section of Lakeside Station, the construction of Deepwater and Holland Stations and a proposed 1800-lb. industrial installation for the Philip Carey Co.

1800 Lb. Industrial Plant Planned in Ohio

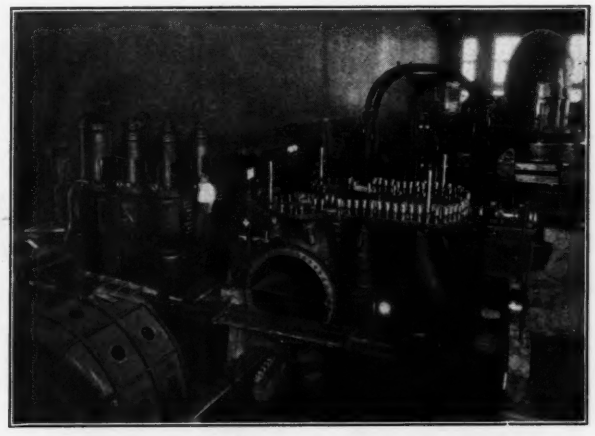
At Lakeside, the new generating equipment will consist of a 7700-kw., 1200-lb. and a 60,000-kw., 325-lb. turbine generator. Deepwater is to be the first station designed entirely as a 1200-lb. plant and the generating equipment consists of two 53,000-kw. cross compound units with 12,000-kw. high-pressure and 41,000-kw. low-pressure elements. Another interesting feature of this plant is the arrangement made with the DuPont Co., whereby the industrial plant will purchase 450-lb. steam for process work, this steam to be the exhaust from a third high pressure turbine which will be a duplicate of the high-pressure elements of the cross-compound sets.

Ordinarily central stations take the initiative in new developments and for this reason the Philip Carey Co.'s 1800-lb. plant will be doubly interesting because it will be not only the highest pressure power plant for any service in this country but the largest superpressure plant in the world. It is expected that the capacity will be 10,000 kw., the boiler equipment to be built in this country and the prime mover, a triple expansion reciprocating engine built in Germany.

Records for All Types of Machines Broken

This year, the 75,000-kw. straight expansion or single cylinder turbine at Huntley Station has the distinction of being the largest turbine of this type ever constructed, having a capacity of 10,000 kw. greater than the similar 65,000-kw. unit at Edgar. Long Beach No. 3 has the largest single shaft machine, a 94,000-kw. tandem compound turbine with four condensers while, after many years, Crawford Avenue Station has lost the distinction of having the largest turbine unit in the world, this title passing to Philo for a short time at least, until the completion of the 208,000-kw. unit at State Line some time during the summer of 1929.

The Philo unit, rated at 165,000 kw., is known as a triple cross-compound composed of one 17-stage high-pressure turbine and two 12-stage low-pressure turbines. Each turbine serves a 62,552-kv-a., 11,000-v. generator, while the low pressure elements have in addition direct connected 3000-kw. house generators. Steam is reheated to 750 deg. F. at 132 lb. in a separately fired boiler in contrast to the steam reheaters now in use on the 104,000-kw. unit at Crawford and as proposed for State Line. A reheat boiler is also used on the 55,000-kw. unit installed in the recently completed Powerton Station, the first large station to generate power at 22,000-v.



STEAM CHEST AND HIGH-PRESSURE TURBINE OF UNIT NO. 8 AT HELL GATE STATION, SHOWING THE MULTIPLE THROTTLE VALVES

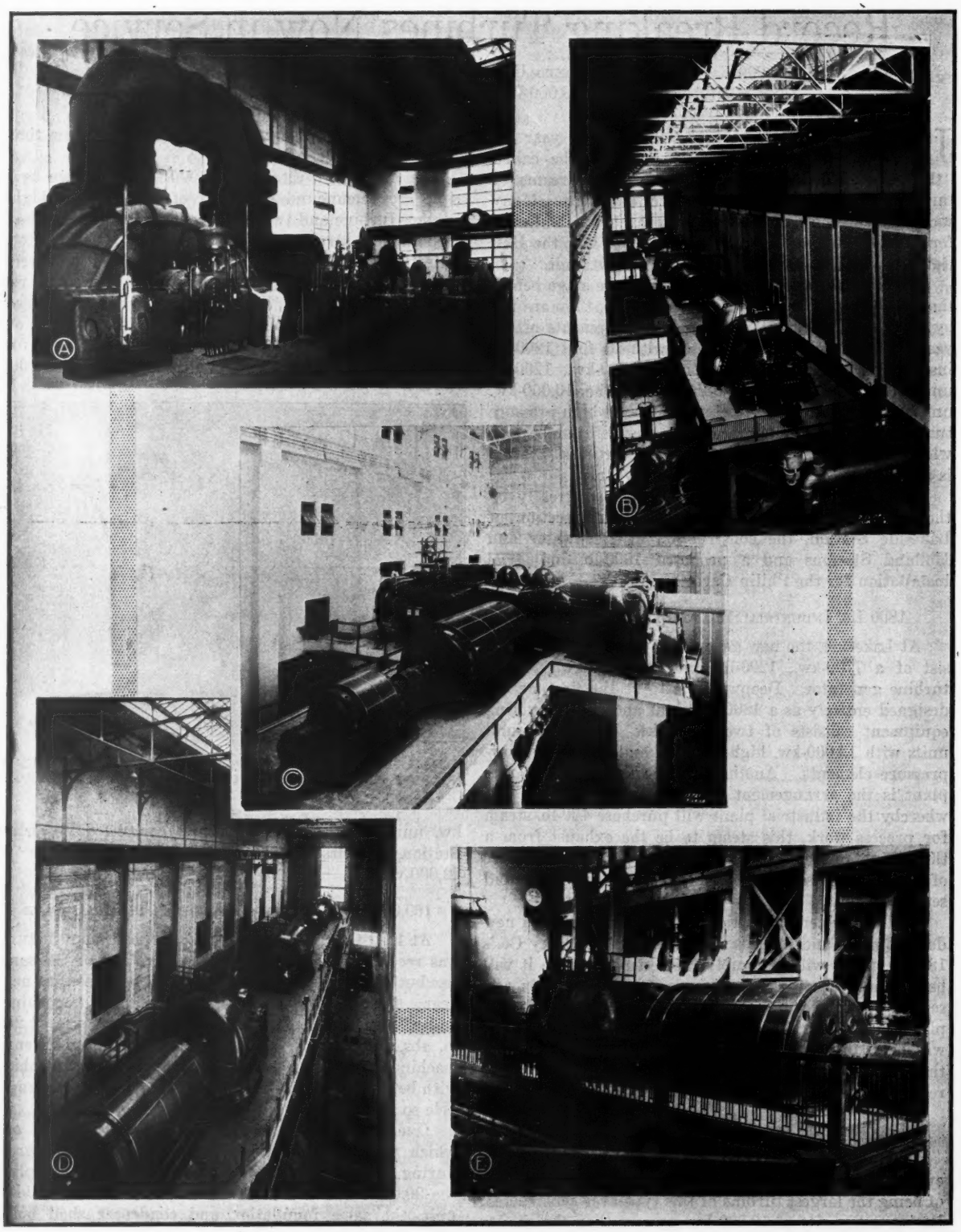
160,000-Kw. European Turbines at Hell Gate

At Hell Gate, Unit No. 8, of European manufacture, was recently put in service and unit No. 9 of the same size but of American manufacture will be in service next year. Both are two-element, cross-compound machines and will operate on the regular station pressure of 280 lb. abs., 700 deg. F. The 110,000-kw. Hudson Avenue machine is also a cross-compound, two element machine with both main generator fields similar and interchangeable so they can be used on either rotor.

One of the most interesting developments and one which plainly shows the remarkable turbine progress during the past few years, is the intention to replace the 30,000-kw. unit No. 1 at Cahokia with a 75,000-kw. unit, the same foundation and condenser shell being altered slightly to accommodate the larger machine.

European Plants Show Practicability of 850 Deg. F.

As yet, no effort has been made to use temperatures of over 750 deg. F. although several European plants are in successful operation using temperatures of up



NOTABLE POWER PLANT CONSTRUCTION HAS NOT BEEN CONFINED TO ANY ONE SECTION OF THE COUNTRY, AS SHOWN BY THESE FIVE UNUSUAL TURBINE ROOM PICTURES TAKEN FROM WIDELY SEPARATED POINTS OF THE COUNTRY. THEY ARE, A. HUDSON AVENUE, B. CAHOKIA, C. LONG BEACH, D. EDGAR, E. LAKE PAULINE

to 850 deg. F. Advantage of the higher temperature is obvious and inasmuch as a number of manufacturers feel justified in guaranteeing their equipment for 1000 deg. F., prospects of higher temperature plants appear bright.

From two to five stages of extraction from main units are now standard practice, the extracted steam being used for feedwater heating, evaporating and deaerating. Apparently high pressure has little tendency to produce lower turbine efficiencies on properly designed machines, reported tests on some of the newer machines showing consistent results regardless of pressure. Efficiency ratios of 78.3 and 78.4 per cent respectively are reported on the non-reheat turbines operating on 390 and 400 lb. at Valmont and Trenton Channel plants, while 80.7 and 80.0 per cent respectively were

STEAM TURBINES

NAME OF STATION	NO. & RATED CAPACITY OF TURBINES	TYPE	THROTTLE PRESSURE LB. ABS.	THROTTLE TEMP. DEG. F.	EXHAUST PRESS.	STM. FLOW TO THROTTLE LB./HR.	EXTRACTION LB./HR.	EXTRACTION % OF TOTAL	EXTRACTION NO. OF PTS.	EXTRACTION PURPOSE
PHILO (FOR EXTENSION)	1-165,000	TRIPLE-CROSS COMPOUND	615	725	1" HG.	1,516,180	937,870	28.86	5	FEED HEATING & EVAPORATING
CAHOKIA 3RD SECTION	1-50,000	SINGLE CYL.	350	725	1.5" HG.	575,000	138,200	24.0	4	F.W., EVAPORATOR + DEAERATOR
VIENNA, MD. STATION	2-6,000	SINGLE CYL.	320	670	1.5" HG.	63,500	6,420	10.10	2	FEED HEATING
LONG BEACH NO. 3	1-49,000	TANDEM COMPOUND	415	725	0.75" TO 2.0"	1,025,000	266,600	26.05	4	FEEDWATER + EVAPORATOR
KEARNY (FOR ADDITION)		NO NEW GENERATING EQUIPMENT INSTALLED								
BINGHAMTON (FOR EXTENSION)	1-35,000	SINGLE CYL.	400	700 TO 725	1.25" HG.	300,000	35,450	11.82	2	FEED HEATING + EVAPORATOR
HELL GATE (FOR EXTENSION)	2-160,000	CROSS COMP.	280	700	1" ABS.	1,750,000	190,000	10.87	2	FEED HEATING
SAGINAW RIVER (FOR EXTENSION)	1-30,000	SINGLE CYL.	365	700	1" HG.	302,100	49,000	16.60	4	FEEDWATER + EVAPORATOR
STATION "C" PIG-E CO. (FOR ADDITION)	1-37,500	SINGLE CYL.	430	700	1.5" HG.	428,000	108,100	25.30	4	FEEDWATER + EVAPORATOR
HORSESHOE LAKE STA. (FOR EXT.)	1-30,000	SINGLE CYL.	275	700	1.5" HG.	330,000	53,000	16.05	3	FEED HEATING + EVAPORATOR
EDGAR (FOR EXTENSION)	1-65,000 1-10,000	SINGLE CYL.	365 1215	725 700	1" HG. 340 "ABS	675,000 705,800	153,350 0	22.67 0	4 0	FW, EVAP + DEAERATOR 0
HUDSON AV. (FOR EXTENSION)	1-110,000	CROSS COMP.	400	706	1" HG. ABS.	1,130,000	188,370	16.67	2	F.W. HEATING
GOULD ST.	2-36,000	SINGLE CYL.	405	700	1.5" HG.	903,000	91,000	22.60	4	FW. HTG. EVAP. DEAERATING
TORONTO (FOR EXT.)	1-30,000	SINGLE CYL.	385	680	1" HG	348,800	99,900	13.83	3	F.W. HEATING & EVAP.
TRINIDAD	2-20,000	SINGLE CYL.	340	700	1.75" HG.	236,900	56,250	23.7	3	FW. HEATING & EVAP.
UNIT NO. 5 CRAWFORD	41,500	CROSS COMP.	865	780	1" HG.				4	DITTO
UNIT NO. 6	104,000	CROSS COMP.	865	725	1" HG.				4	DITTO
LAKE PAULINE	1-15,000	SINGLE CYL.	340	700	1" HG.	174,500	29,900	1.69	4	DITTO
U.S. RUBBER CO.	2-5000 1-3,000 1-3000	SINGLE CYL. " "	200	538	3" HG. 3" HG. 20 LB.	48,000 40,000 155,000	24,000 & HIGH BACK PRESS.	25 & 0	2 & 0	FW. HTG. + BLDS HTG. BLDS. HTG.
ACHESON HARDEN	1-200	UNIFLOW ENGINE	200	510	20 LB.	5,000	HIGH BACK PRESS.		NO. EXTRACTION	
PISTON RING CO.	1-1000	UNIFLOW ENG.	175	630	6LB. ABS.	25,000				
ANGLO CANADIAN	1-7,500 KW.	SINGLE CYL.	340	640	40LB. ABS.	215,000	52,000	24.2	1	PROCESS & HEATING
SORG PAPER CO.	2-5,000	SINGLE CYL.	375	725	2" HG.	120,000	21,300	17.9	2	MILL PROCESS
STANOLIND	3-3500 1-1250 2-1000	SINGLE CYL.	340 140 140	635 450 450	PROPANE 22 - 25 -	221,000 59,000 43,000				

reported for the low and high-pressure turbines at Columbia. At Lakeside, the efficiency of the 1200-lb. turbine has been increased to about 80 per cent largely by correction of interstage leakage.

Up to 65,000 or 75,000 kw., the single flow, single cylinder machine continues to be favored while above this the two or three-element cross compound is favored. The tandem compound favored by some European manufacturers is not to become as popular in this country as conditions two or three years ago seemed to indicate. A second 94,000-kw. tandem compound unit will be installed at Long Beach, however, and the 165,000-kw. tandem compound unit for East River is under construction, indicating that the tandem compound unit will not pass out of the picture entirely.

At Columbia the 50,000-kv-a. tandem compound units are being rebuilt into 76,800-kw. cross compound units. The high-pressure elements of the present turbines are being removed and the reheat pressure raised from 100 to 185 lb. in order that the low-pressure section can carry the generator rating formerly carried by the tandem compound unit.

In addition to larger and more efficient turbines, the reduction in weight and floor space has been remarkable. In 1914, a typical generating unit weighed 42.5 lb. per kw. and required 59 sq. ft. of floor space per 1000 kw. The 165,000 kw. Hell Gate Unit No. 9 will weigh 14.9 lb. per kw. and occupy but 39 sq. ft. per 1000 kw. Unfortunately, due to more expensive material and construction, there has not been a proportional decrease in cost.

No review of the year's progress would be complete without mention of the mercury vapor installation at the South Meadow Station. The mercury turbine, a 10,000-kw., 5-stage machine using 70 lb. mercury vapor, has been in operation for several weeks and data on its operation and performance will be available sometime during the first part of 1929. Operation of the station, which has a steam capacity of 40,000 kw. in addition to the 10,000-kw. mercury turbine, shows a decided improvement in full economy when the mercury vapor equipment is in service.

Results to date have convinced some of the most skeptical engineers of the practicability of the process, and although the majority are withholding criticism or approval until more data is available, it is generally felt that the steam cycle has about reached the highest possible thermal efficiency and any further improvements must come from an entirely new or binary vapor cycle. The South Meadow Station has demonstrated that economies of 8000 to 9000 B.t.u. per kw-hr. are not as visionary as they appeared to be a few years ago.

Marked Decrease Shown in Condenser Surface

Smaller Unit Surfaces and Increased Condensing Efficiency Mark Year's Progress

FOLLOWING the general trend of the past few years, condenser surface per unit of turbine capacity continues to decrease and it is expected that a figure of 0.5 sq. ft. per kw. of capacity will be reached in the near future. This figure will be closely approached by the 90,000-sq. ft. condenser for the new 160,000-kw. East River unit. This is a ratio of 1 to 0.562. This reduction in area is noticeable in both one and two pass single and multiple shells. Limited space, improved water rates of turbines and increases in the amount of bled steam are factors influencing this change.

That this unit is no longer of any practical use in comparing condenser design and performance can be seen from an inspection of the third and fifth columns in the table. For instance, Philo has about half the surface per kilowatt of Cahokia and yet the latter condenser condenses 12.8 pounds of steam per kw-hr. while the former condenses but 10.8 lb. per kw-hr. Similarly with the Philo and Hell Gate installations, unit surfaces are 0.61 and 0.80 respectively for these two stations and the corresponding unit condensing rates are 10.8 and 11.3.

Reasons for these apparent discrepancies can be found in the turbine table. Practically 29 per cent of the total steam is extracted at Philo against 24 per cent at Cahokia and 11 per cent at Hell Gate. Also the water rate at Philo is much lower due to the higher pressure and reheat. At Philo the flow of steam per kilowatt to the throttle is 7 lb. against 11.5 at Cahokia and 10.9 at Hell Gate.

One of the most interesting details of condenser design is the apparently successful use of condenser

tubes rolled at both ends. Some condensers of this type are built with one movable tube sheet, but the Gould Street condensers, after elaborate and exhaustive experiments, were built with stationary tube sheets, all tube expansion being taken up by bending of the tubes.

Rolling both ends of condenser tubes is, as yet, the exception rather than the rule, although an increasing number are rolling tubes at one end, using corset lace, fibre or metallic packing on the other. Admiralty tubes are by far the favorite, the tendency apparently being toward the increased use of 7/8 and 3/4-in. tubes.

Practically all auxiliaries are now motor driven, using 440 or 2200 v. supplied either from transformers or shaft generators. A small number, especially industrial plants or those on the smaller systems, still feel that this practice is not absolutely dependable and use steam either normally or as standby. At Hudson Ave., auxiliaries are supplied from tertiary windings on the main transformers.

Auxiliary Drives Receiving More Attention

The general tendency is toward the higher voltages of 2200 v., across the line starting and the use of multiple speed motors. This tendency has been noticeable for some time in connection with circulating pumps but is comparatively recent in connection with condensate pumps. These pumps, even under the best conditions, are subject to hard service. This has led to the introduction of variable speed drive or some other method of maintaining steady conditions of operation. At Long Beach, an automatic regulator is used to maintain a constant level in the hotwell, makeup being supplied from and the excess going to a condensate surge tank.

At Station C, a 500-hp. synchronous motor drives a circulating water pump. This is started, in the same manner as the other auxiliary motors, without the use of starting equipment, other than minor control equipment for regulating the field. Advantages of this type of motor are low first cost for low speeds, unity power factor and high efficiency, in this particular case, 94 per cent.

Outside of the increased number of vertical circulating pumps, of the type installed at Crawford, there has been no noticeable auxiliary developments. Three stage ejectors are becoming more popular and more widely used, although both Edgar and Cahokia still prefer the rotative dry vacuum pump.

Little change is reported in the proportion of divided boxes used and the tendency toward the use of expansion joints between the condenser and turbine continues. Figure 1A shows the type of expansion joint which will be used on Hell Gate Unit No. 8. This turbine has two exhaust openings. The connection between the condenser and turbine is rigid on one opening, while a special connection to allow some lateral movement is used at the other.

This device consists of a number of steel balls inserted between two steel plates. Exact adjustment can be made with the lower disc by means of a threaded screw. The joint is made air tight by means of a rubber ring inserted between the flanges. This ring is

CONDENSERS AND AUXILIARIES

NAME OF STATION	SURFACE		STEAM FLOW TO CONDENSER		TUBES	PACKING	PASSES	CIRC. PUMPS			GPM CIRC WATER PER KW.	STM. RATIO LB H_2O/ LB. STEAM	COND. PUMPS			VAC. PUMPS			SOURCE OF AUX. POWER
	SQ. FT.	SQ. FT./KW.	LB./HR.	#/HR/SQ.'	NO.+O.DIA.			NO. PER COND	CAPACITY EACH GPM	DRIVE			NO.	CAP. LB/HR	DRIVE	NO.	TYPE	TOTAL CAP. C.F.M.	
PHILO 1928 EXTENSION	2-50,000	0.61	539,155 EACH	10.8	7/32 EACH 1"OD. NO.18 BWG ADMIRLTY	1 END ROLLED 1 " FIBER	1	2	50,000	2300 V. INDUCTION MOTOR	1.21	93	4	699,720	2300 V. VAR. SPEED IND. M.	2	STEAM JET	40	HOUSE GEN.
CAHOKIA 3RD SECTION	56,000	1.12	437,000	12.8	10,710 1 IN. 18 BWG. ADM.	CORSET LACE	2	2	70,000	2200 V. 4 SPEED IND. M.	1.40†	80	2	686,000	2300 V. IND. M.	1	R.D.V.	40	HOUSE GEN + HS. SERV. TR. ON STA. BUS
VIENNA, MD. STATION	2-6,200	1.03	57,000	9.2	1580 1" 16 BWG. ADM.	METALLIC	2	3*	6,800	440 V. MOTORS	1.47†	77	2	87,500 "	CONSTANT SPEED MOTOR	2	STM. JET	6.9	MAIN UNIT
LONG BEACH NO. 3	4-20,000	0.85	190,000 EACH	9.5	4400-7/8" EA. 16BWG. ADM.	FIBER + METALLIC	1	2†	82,500	2200 V. IND.M.	1.76	108	3	425,000	2200 V. IND.M.	5	STM. JET		AUX. SHFT. GEN. + TURB GEN.
KEARNY 1928 ADDITION	NO NEW CONDENSING OR GENERATING EQUIPMENT INSTALLED																		
BINGHAMTON 1928 EXTENSION	22,000	0.628	264,550	12.0	4620-7/8" 17 BWG. ADM.	ROLLED + CORSET LACE	1	2	16,000	125 HP SQ. CAGE IND. M.	1.17	68	2	275,000	1-TURB. 1-40 HP. IND. M.	2	STM. JET	250	HOUSE TRANSF.
HELL GATE 1928 EXTENSION	2-68,750	0.80	780,000 EACH	11.3	16,000 3/4" EACH 18 BWG. ADM.	CORSET LACE	2	1	77,500	500 HP. 2 SPEED IND. M.	0.97	50	3	875,000	100 HP. IND. M.	3	STM. JET	64	HSE. GEN + TRANSF.
SAGINAW RIVER 1928 EXTENSION	30,000	1.00	258,100	8.6	7650-3/4" 18 BWG. ADM.	ROLLED + CORSET LACE	1	2	29,000	440 V. IND. M.	1.93	112	2	400,000	440 V. IND. M.	2	STM. JET	19.2	HOUSE GEN. OR DUPLICATE TRANS. BANKS
STATION "C" P.G.+E.CO. 1928 EXT.	28,000	0.75	320,000	11.4	18 BWG. BRASS	ROLLED METALLIC	1	SUPPLIED FROM COMMON STATION SYSTEM			1.60	88	2	400,000	2300 V. SLIP RING M.	2	3 STG. STM. JET	40	AUX. TR. BANKS FROM STA. BUS
HORSESHOE LAKE STA. MDBEX	35,600	1.19	280,000	7.87	6800 1" 18 BWG. ADM.	METALLIC	2	2	30,000	2300 V. IND. M.	1.00†	72	1	400,000	STM. TURB.	2	STM. JET	40.3	STA. TRANS. BANK
EDGAR 1928 EXTENSION	51,200	0.78	521,650	10.19	9930 3/4" 18 BWG. ADM.	CORSET LACE	1	2	70,000	2200 V. VAR. SP. IND. M.	1.08†	67	2	676,000	2200 V. CONST. SP. 130 HP.	1	PISTON PUMP	1,060	AUX. SHAFT GEN.
HUDSON AV. 1928 EXTENSION	85,000	0.77	991,630	11.06	14,400 3/4" 16 BWG. ADM.	FIBER + ADMIRALTY FERRULES	1	2	67,500	2300 V. 2 SPEED IND. M.	1.23	71	2	950,000	2300 V. 2-SPEED	2 – 1 –	STM. JET HYDROLIC	167 48	TERTIARY WINDINGS ON MAIN AUTO TRANS.
GOULD ST.	2-30,000	0.83	304,340	10.10	7363 3/4" 18 BWG. ADM.	ROLLED BOTH ENDS	2	2	20,000	440 V. MOTOR	1.11	66	2	400,000	440 V. MOTOR	1	STM. JET	75	SHAFT GEN.
TORONTO 1928 EXT.	30,000	1.66	312,300	6.25	9870-1" 18 BWG. ADM.	METAL EXPANDED + METALLIC	2	2	30,000	200 HP. 2 SPEED IND.	2.00	96	2	375,000	40 HP MOTOR	4	STM. JET	92	HOUSE GEN.
TRINIDAD	20,000	1.00	177,150	8.85	1528-3/4" 18 BWG 1176-3/4" " 1284-1" ADM.	ROLLED	1	2	20,000	2200 V. 2 SPEED IND.	2.00	113	2	220,000	2200 V. IND.	1	STM JET	?	MAIN GEN. THROUGH TRANSF.
CRAWFORD 1928 EXT.	2-35,260 6-13,000	0.77 0.86	? ?	ABT. 10 " 8	7186-1" EACH 3320-5/8" "	FIBER + ROLLED	2 1	2† 2†	60,000 45,000	2 SPEED CONST. SPEED	1.33† 1.83	? ?	3 3	600,000 "	CONST. SPEED	2 2	STM. EJECTORS	? ?	SHAFT GEN.
LAKE PAULINE	17,000	1.13	150,000	8.83	1" NO. 18 ARSENICAL COPPER	FLOATING HEAD – NO PACKING	1	1	36,000 (15,00 GEN. AIR COOLER)	250 HP IND.	2.43	122	2	192,000	40 HP. SLIP RING	1	TWIN STM. JET	34	AUX. TRANS. BANK
U.S. RUBBER CO.	2-10,000 1- 5,000	2.00 1.66	75,000 40,000	7.50 8.00	3181-3/4" NO. 18 1592- " " "		2 2	2 1	8,000 5,850	1-DUAL 1-MOTOR DUAL	3.20 1.82	100 136	2 1	140,000 ?	1-TURB. 1-MOTOR MOTOR	1 1	STM. JET	18.87 18.87	TRANSF. FROM MAIN BUS
ACHESON HARDEN	NO CONDENSING EQUIPMENT INSTALLED																		
PISTON RING CO.	DITTO																		
ANGLO-CANADIAN	DITTO																		
SORG PAPER CO.	8-6,000	1.2	40,000	6.60	1910-3/4" NO. 18 MUNTZ		2	1	5,000	VAR. SP. IND.	0.83	62	1	110,000	IND. MOTOR	1	STM. JET	?	HYDRO PLANT
STANOLIND	NONE																		

†-ONE PUMP OPERATING *- WILL BE PART OF COMMON SYSTEM #- SUPPLIES ALL CONDENSERS

made hollow in order to allow the circulation of cooling water through it for the double purpose of cooling it at low vacuum periods and to increase the pressure of the rubber against the metallic surfaces. The rubber

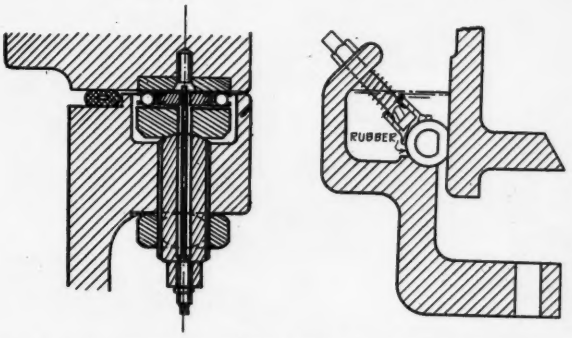


FIG. 1. A. FLEXIBLE EXPANSION JOINT USED ON THE 160,000-KW. HELL GATE UNIT NO. 8. B. EXPANSION JOINT OF THE TYPE USED AT CAHOKIA STATION

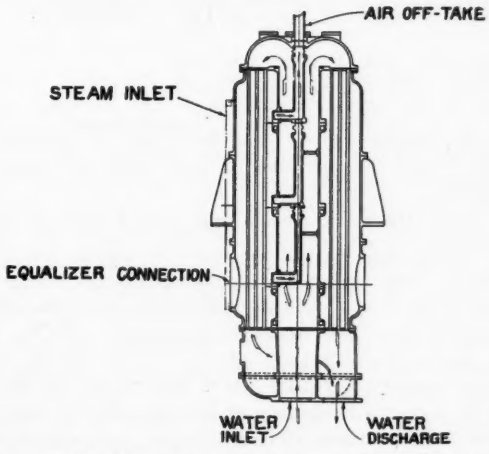


FIG. 2. HOTWELL AND AIR COOLER SECTIONS ON TWO RECENT CONDENSER DESIGNS

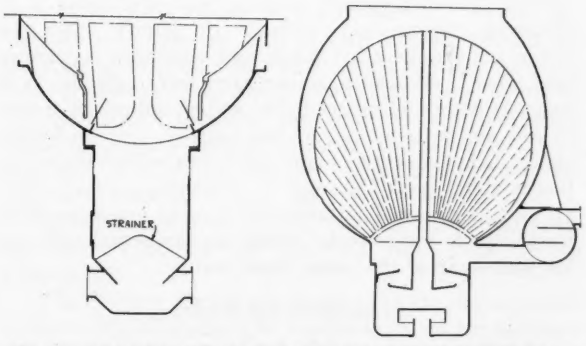


FIG. 3. ARRANGEMENT OF THE VERTICAL SINGLE PASS CONDENSER FOR THE 104,000-KW. UNIT AT CRAWFORD AVE.

ring is located on the outside of the joint where it is accessible while the bolts and bearing mechanism are located on the inside. These parts are made of non-rusting material so as not to be affected by the steam and water with which they come in contact.

In addition to the expansion joint, the Hell Gate

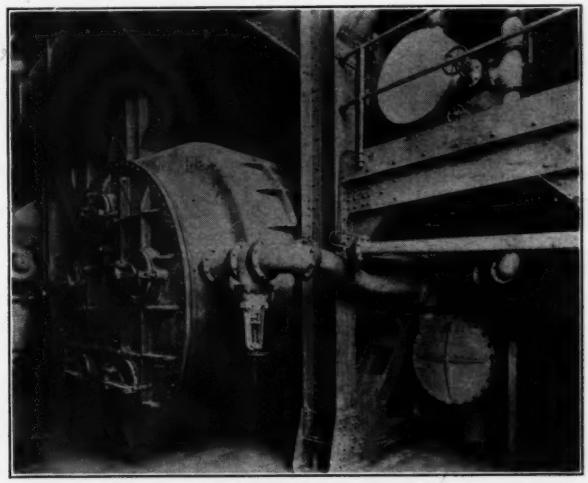


FIG. 4. CONDENSER AND EXTERNAL AIR COOLER AT THE HUTCHINSON (KANSAS) STATION

condensers themselves are of novel design. Each 160,000-kw. turbine will have a 137,500-sq. ft. condenser, each condenser being divided into halves placed end to end with a water box in the center. Circulating water enters the bottom of the central water box through pipes under the basement floor. Since these are two pass condensers, the discharge is from the top of the same box. Space limitations were such that the design had to allow pulling the tubes from one section, through the tube sheet of the other shell.

An external air cooler is provided and air removal is taken care of by three stage air ejectors. Motor driven condensate and circulating water pumps are used, the latter being a capacity of 100,000 g.p.m. at normal speed or 155,000 g.p.m. at full speed.

External air coolers were also used at Edgar with the new single pass condenser. A somewhat more novel feature of this unit is the external hotwell connected to the condenser by pipes.

Another novel design is illustrated by the six 15,000-sq. ft. condensers serving the 104,000-kw. turbine at Crawford Ave. An attempt has been made to hide all circulating water piping as shown in Fig. 3. Water enters bottom of the condenser through a central conduit located within the tube nest, enters the top of the tubes and flows downward. Air is removed at the side remote from the steam inlet, air collecting ports being located around the central water conduit.

In this design the water flow is just opposite to that in the eight 22,000-sq. ft. condensers which will serve the 208,000-kw. State Line Unit. In these eight condensers water enters the tubes through the bottom, flows upward and is discharged downward through passages cast integral with the shell.

In general, the use of single-pass condensers is increasing. This is particularly true of condensers which serve the larger units, the greater part of the single pass surface being installed on units of 50,000 kw. or over. This is not due to any overwhelming superiority of the single-pass condenser but rather to its flexibility of design and the ability to meet particular and limited space conditions, a prime requisite for the modern plant where the increasing size of units constantly presents new problems of design, construction and installation.

Hydroelectric Developments During 1928

TYPES OF UNITS USED, INSTALLATION DESIGNS AND TENDENCIES AND PROBABLE COURSE OF FUTURE DEVELOPMENT. BY EDWARD M. BURD*

ECONOMIC STATUS of water power in general and its relation to competing forms of power generation is perhaps the most important consideration of the subject. Any such basis of comparison assumes immediately that water power development must be economically justified, as sharply distinguished from projects involving political expediency, popular demand and other qualifying and confusing issues. The unjustified prominence during the past year of unworthy schemes and projects will certainly react ultimately to discredit all water power. Progress in this sense is not forward.

Limiting consideration to the strictly economic problem, it is evident that other methods of electric power generation considerably restrict the field and prospects of water power for the immediate future.

USES OF STEAM AND WATER POWER ON BASE LOAD

In the eastern portion of the United States and Canada, steam generation for base loads of any considerable magnitude can generally produce energy at a smaller total over-all cost than is possible by means of remaining hydroelectric projects as yet undeveloped. The most economical water powers are obviously already in service and each successive development involves increasing fixed charges, whereas each successive steam plant represents an advance in the art.

There appears to be an increasing tendency to meet this condition by operating combined systems so as to carry base load on steam power and peak load on water power during all except high water periods. This arrangement appears to be gaining favor with practically all of the large utility systems, including some which have until recently continued developing water power for the base of the load. With some 95 per cent or more of the hydroelectric plant costs in fixed charges, but only about 50 per cent for steam, it appears inevitable that this division of load must ultimately be accepted.

RELATIVE FIELDS FOR TWO TYPES

Used in this way, there is an economic division in terms of load factor between steam power and water power, which point will depend upon their relative development costs and operating expenses. But in general, in the eastern part of the United States, under present conditions future water powers can be justified only if they are to operate at less than 40 per cent load factor. This means that attractive projects must at least have ample load factor pondage, large installed capacity and good low water ability either by virtue of a well-sustained low water flow or artificial storage. Except under special or peculiar load conditions, it is becoming increasingly difficult to justify river-run projects. On the other hand, this condition is making peak load hydroelectric power even more valuable as it becomes better understood that water and steam power should not be compared on the basis of average kw-hr. costs. A hydroelectric plant which can relieve the steam plants of the peak load may be absorbing a peak which, all costs considered, would cost twice as much per kilowatt-hour to generate by steam, as the actual cost per kilowatt-hour of the steam base load.

INTERCONNECTED SYSTEMS

Another promising field for hydroelectric plants concerns the load exchange possibilities of interconnected plants and systems. Peak hydroelectric plants of large pond storage offer exceedingly profitable energy reservoirs as storage battery plants for the accumulation and conversion of off-peak or dump steam into peak load energy at, of course, an enormous advance in value. Perhaps the most attractive water power projects during the year 1928 have been approached along these lines. Some all-steam systems in the southwest, having

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sharp peak loads, apparently justify the construction of "storage battery pumping plants" for the sole purpose of absorbing the short, sharp peak, the only requirement for this situation being two adjacent reservoirs with preferably 200 to 400 ft. difference in elevation, the water being used over again any number of times, pumped up on off-peak and generating on peak. Some of these plants will likely be built in the near future.

Steam and Water Power Reliability

Reliability of service is of equal or greater importance in meeting present day power demands. Summarizing reliability data systematically gathered throughout the utility field during the past four years, the records show that a modern hydroelectric unit together with a single circuit transmission line 100 mi. long and including all of the elements of outage attending the entire water power plant and line, affords a demand serviceability factor of about 98.6 per cent as compared with a steam unit and its boiler plant and coal handling machinery averaging about 94 per cent. These figures never fail to excite heated argument between steam and hydraulic engineers but are matters of fact which should be given consideration.

It is interesting to note that the present installed hydro capacity in North America, aggregating somewhat over 19,000,000 hp., constitutes only about one-fifth of the available water power on the continent. While this available power, according to Government statistics, comprises only 14.5 per cent of that of the world, the present installed capacity in North America is about one-half of that throughout the world. Also the world's installed capacity increased 43 per cent in the six years ending with 1926 and three-quarters of this increase was in the United States and Canada. Summarizing the economic situation, it seems certain that water power will not fail to maintain its present position unless unable to adapt itself to the everchanging economic conditions.

Statistics on Current Installation

No yearly summary of the situation would be complete without reference to the larger and notable installations during the year as indicated by the accompanying tabulation, collected from all available sources. For comparison, some older plants have been included. This tabulation indicates the tendency towards larger capacity so-called peak plants for operation in mixed systems. Engineering capital apparently is most attracted to and justified by this type of development.

One manufacturer reports total contracts aggregating over 1,000,000 hp. for the year 1928 up to October 15.

The Chute-A-Caroti development in Quebec, as noted on the table is reported to have contracted for turbines which perhaps will be the largest in water capacity yet manufactured.

Machinery Design and Construction

As for type of generating equipment, with inconsequential exceptions the present tendency is toward large-capacity, single-runner, direct-connected vertical units. The desirability of capacity seems limited only by physical dimensions, design stresses and specific speed as affecting cost of equipment. For units like Conowingo and Louisville, the physical dimensions and water capacity have increased enormously but with actual saving in cost per kilowatt of capacity both for machinery and the power house structure. The limit in size is perhaps not yet reached.

Turbine types are fairly well standardized and undergoing but little change except for propeller types. Pelton type impulse wheels practically monopolize the field for all high heads, down to about 600 ft. head. These units usually consist of two runners overhung at the ends of a horizontal shaft, with the generator mounted on the center of the shaft between two pedestal bearings. Modified Francis types on horizontal or vertical shafts are used for heads of 700 ft. down to as low as 100 ft. for small units. For large capacity units at heads from 200 ft. down to approximately 30 ft. head, a single runner of Francis type on vertical shaft, direct connected to generator at top of shaft, with thrust bearing just below the generator, seems to serve the purpose best. Propeller types of the same general unit arrangement were originally developed for very low heads but of late have been modified and adapted to heads as high as 56 ft., but at some sacrifice in efficiency to meet other conditions.

Plant	Operating Companies	No. Units	Power HP	Head	R.P.M.	Full Gate C.F.S. Approx.	Sp. Sd.	Type
Keokuk	Miss. Riv. Power Co.	15	10,000	32	57.7	3,200	75.8	Francis
Louisville	Louisville Hydro. Elec. Co.	8	13,500	37	100	4,000	127.7	Propeller, single runner vert.
High Rock	Tallassee Power Co.	3	14,700	52	90	3,040	78.2	
Upper Tallassee	Dixie Const. Co.	2	25,000	55	80	4,900	84.3	Francis, single runner vert.
Winnipeg, No.	Manitoba Power Co.	6	28,000	56	138.5	5,400	53.	Propeller, " " "
Bellows Falls	New England Power Co.	3	17,500	57	85.7	3,300	72.3	Francis, " " "
Norwood	Carolina Power & Lt. Co.	2	31,100	70		4,775		" " "
"	" " "	1	25,600	70		3,930		" " "
Conowingo	Susquehanna Power Co.	7	54,000	89	81.8	6,500	68.7	" " "
Jordan Dam	Alabama Power Co.	4	36,600	90	100	4,300	68.8	
*Orford	N. Carolina Power Co.	2	28,000	90		3,350		
Muscle Shoals	U.S. Government	8	30,000	94	100	3,200	38.2	Francis "
Pougan	Gatineau Power Co	6	34,000	132	125	2,770	51.5	" "
*Chute-a-Caron	Alcoa Power Co.	4	73,600	165	120	4,925	53.8	Francis "
Niagara	Niagara Falls Po. Co.	3	64,000	213	150	4,250	38.7	Francis
*Saluda	Lexington Water Po. Co.	4	33,650	180	138.5	3,140	43.6	" "
*15 mi Falls	Conn. River Dev. Co.	4	43,000	165	138.5	2,640	48.6	" "
Prospect #2	California Oregon Po. Co.	2	23,400	590		427		
*Waterville	Carolina Power & Lt. Co.	2	49,000	733	400	700	22.3	
Big Creek #3	So. Cal. Edison Co.	1	35,000	440	428	480	20.95	
" " #2A	" " "	1	56,000	2200	250	135 ea.		Pelton, double runner: hol.
Buck Creek	Feather River Power Co.	2	30,000	2480	450	130		" , single "

* Not yet in operation.

than the equivalent opening; unless very carefully designed and proved out in practice, some of the troubles alluded to are likely to be encountered and frequently have been.

Adjustable-Blade Types

Adjustable-blade propeller types are now being developed in this country to cover the operating field of low heads even more completely than the fixed-blade propeller. While European experience with these units has been going on during the past five years with an installation of 57 units of a total capacity of 150,400 hp. up to August, 1928, this country has seen but relatively little of them as yet. Apparently only one American company has any actual installations in this country now in operation and these consist of some 30 installations beginning with 1924 and containing units up to 6000 hp. in capacity and 32 ft. head.

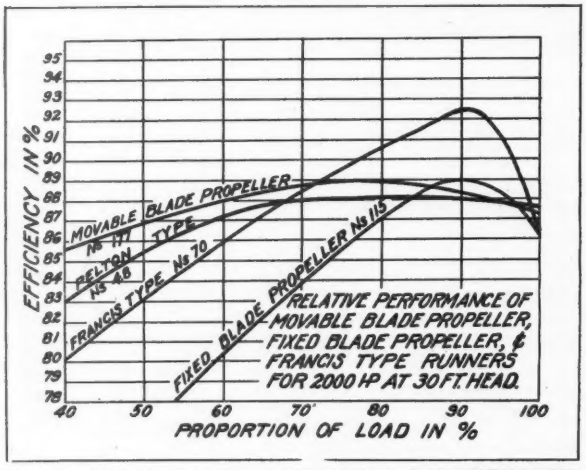


FIG. 1. AVERAGE CURVES OF POWER AND EFFICIENCY FOR FOUR USUAL TYPES OF RUNNERS

This locked adjustable type is provided with a manually-operated locking mechanism, which rigidly fixes the blade position and requires a few minutes shutdown of the unit if resetting of the blades is desired. This locked type is, in general, safer and more economical, in that it permits of the least possible operating clearance and obviates any chance of lost motion or vibration in the mechanism. European practice has developed a governor control adjustment so that the blade angle is adjusted in proportion to the gate opening and head. Any advantages of this further refinement have not yet been reflected in this country by actual installations. It is understood that a recently placed contract for the Back River Plant of the Montreal Island Power Co. calls for six units of this locked type of 12,000 hp. each, the contract being split between two manufacturers.

Advantages of the adjustable-blade runner are its adaptability of characteristics to suit widely varying heads and quantities of water. In time of high water and low head, it can be set to pass a much larger flow and develop about 50 per cent more power at a given head than would be possible with a fixed-blade wheel. Similarly, in times of low flow and high head, the adjustment permits of maximum operating economy. In this way additional output is secured at each end of the duration curve with consequent appreciation in the annual output of the unit and frequently a considerable part of this increase is in prime power. High water can be converted into energy far beyond the capacity of any other turbine. The increased cost of this adjustable blade type is in general from 10 to 20 per cent, which includes the total unit cost with generator.

Efficiency and power characteristics of these four usual types of runners under average conditions are as shown on Fig. 1. Average curves of this nature cannot, of course, represent unusual conditions. In some cases higher efficiencies have been obtained from propeller types than here shown and during 1928 several tests of Francis turbine installations made by reputable test authorities have shown turbine efficiencies approximating 94 per cent, but average conditions will be about as shown on Fig. 1, particularly for installations which are not of large capacity and which cannot afford nicety of refinements essential to highest efficiency. Under exceptional circumstances, any of these curves can be improved two per cent, which is about the limit of present realization and leaves small margin for the future. Obviously this margin will be narrowed somewhat slowly.

Materials and Details of Construction

Materials and details of turbine construction show no great change during the year except as regards refinements of design and better materials and workmanship. For Francis turbines of moderately low head and relatively small size, die-formed, steel-plate buckets cast into hub and belt are entirely suitable if well designed and constructed. Single-piece, cast-iron runners will always be purchased on a price basis if suitable for that purpose. It is noticeable that for large runners there is a strong preference for cast-steel construction. Advantages of bronze or other alloys for particular purposes and conditions may be justified but some have not been. For propeller types there has been breakage difficulty with cast-iron construction and it would seem advisable, whenever possible, to use only cast steel for this type of runner. Welded construction of generators, spiders, pit liners, and so on, has come into considerable prominence during the past year and probably this type will ultimately displace most of the castings at some economy but with more certainty as to designed stresses and loadings.

Pitting of runners seems constantly more prevalent but less serious because of the advances in the welding art. It is generally agreed that pitting must be expected with high-speed runners of short blade length when set with the high draft head now prevailing. The latter is, of course, desirable to improve draft tube conditions and to secure economy of construction and ease of inspection. Recent tendencies indicate a recession somewhat as regards height of draft head. This improvement, together with a slightly longer runner blade and constantly improving blade design, will obviate most of the pitting.

Bearings and Other Details

Turbine bearings for horizontal installations where the bearings are submerged will perhaps continue to be of adjustable lignum vitae block construction with or without pressure grease lubrication, the value of the latter being debatable. For the usual form of dry-pit vertical unit, there is a definite tendency towards oil-lubricated, babbited bearings, particularly for large

size units. Some difference of opinion exists as to whether these should or should not be made adjustable, operators apparently desiring the advantage of adjustment. Rubber-faced bearings are not in general showing any decided advantage and some have proved unsatisfactory.

Painting of turbines is a proved advantage in watching for signs of pitting or indication of erosion. Only higher grade enamels appear to give satisfactory results on turbine runners. Some experiments during 1928 on turbines operating under identical conditions have proved that a high-grade asphaltic enamel applied directly to a clean runner surface is far superior to the same enamel applied over a priming coat of red lead or any combination of lead-oil paints.

Venting of turbines at gate openings up to four-tenths is a proved and recognized advantage. It secures increased output and greater stability but is open to the noise objection from an operator's viewpoint. The answer to the latter is that for reasons of economy a turbine should be noisy up to four-tenths gate, the more noisy and unbearable the better. Venting is essential for synchronous condenser operation and is usually installed for this reason, if for no other.

Installation Designs and Tendencies

Outdoor turbine installations apparently have not increased in favor during the past year. The few such installations now under observation indicate a questionably sufficient advantage in first costs and certainly no advantage in operation. The older idea of a concrete framed stator, unprotected, has necessarily and advisedly been revised to the conventional form of indoor generator with some kind of a "tin hat," served with an outdoor crane of gantry or other form. Several installations of this type are in operation, the most recent and largest being the Norwood Plant of the Carolina Power and Light Co., shown in the headpiece. Whether or not the saving in investment so made warrants the operating difficulties frequently encountered with water lines, cooling air, inspection and repair in bad weather, is a matter of judgment yet to be proved by experience. The saving, at least in some cases, has not been nearly as great as expected. The viewpoint of those not yet convinced is that the relatively small cost of a simple superstructure is well worth its advantages for both tangible and intangible reasons.

Dam design and construction have been subjected to some severe misfortunes during the past year which, in the long run, will be beneficial. One immediate result is the evident need of a broader consulting service on projects involving magnitude or dangerous situations. The evidence does not affect the reliability of any particular type of dam since all have suffered, but the facts show rather the need of more careful thought and attention to details which by habit and custom may become more or less standardized, as distinguished from being studied out anew for each situation.

Study of the difficulties encountered during the past year seems to indicate that all of them could have been overcome by adequately designing for the existing conditions without radically or even appreciably changing the projects as a whole. This seems to be particularly true of foundation conditions. Depreciation of concrete construction is becoming increasingly important with the increasing age of large numbers of these structures. This is particularly true in the colder regions and the answer seems to be denser concrete obtained by richer mixes as more recently developed by scientific designing. No particularly new forms or types have been advanced, except possibly the three-domed Coolidge Dam.

Spillway and gate constructions have been taxed to capacity in numerous instances during the past year and with some decidedly adverse effects upon the spillway channel at the downstream toe. In some cases, additional protection is essential and considerable thought and experimental study have been given to the problem of developing forms and designs which will insure the

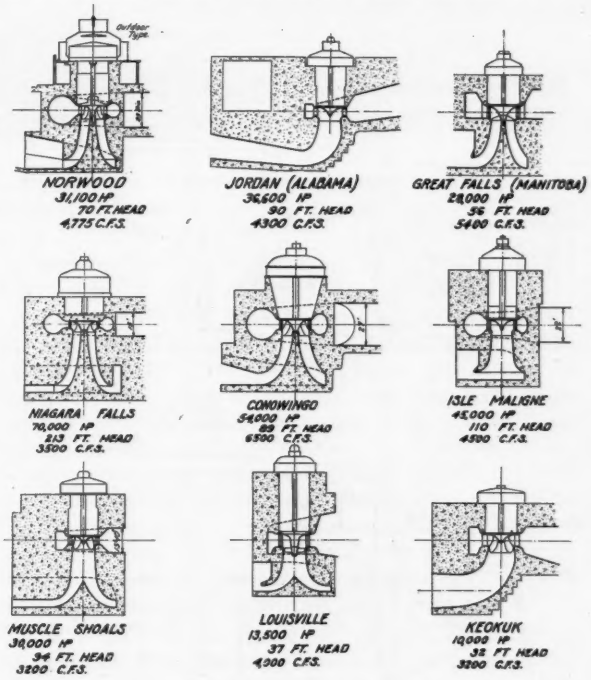


FIG. 2. TYPICAL LARGE CAPACITY UNITS AT MODERATE HEADS

structure and foundation against dangerous erosion by the spilled water.

Present thought appears to favor some form of construction which will insure an adequate body of water at the toe of the spillway so that the dissipation of energy will take place within the hydraulic jump against the water cushion, rather than against adjacent surfaces. In some cases, tumblebay weirs on a large scale are being installed for this purpose. In another notable case, small scale experiments have indicated the shape and slope of downstream toe to throw the spilling stream upward and downstream far enough to insure any erosion being safely removed from the dam. Failure to provide for this condition has been a costly lesson for both large and small developments.

Some notable installations of drum gates have been made where conditions seem to warrant their expense, although the preponderance of opinion still seems to be divided between tainter gates and stony gates. Conowingo gates are perhaps the most notable installation of the latter and at the same plant some wonderfully effective butterfly penstock gates have been developed and installed.

Status of Draft Tube Design

Draft tube design continues to be of major importance and to many engineers the problem is still veiled in uncertainty as regards abilities and efficiencies of different types and their suitability for various installations. The controversy over the relative merits and possibilities, trying to compare them by means of a reference tube or other standardized measure, continues unabated but without as yet tangible results, although the dust is settling slowly.

Consensus of opinion and study of the mass of unconvincing test data seem to indicate that, for runners

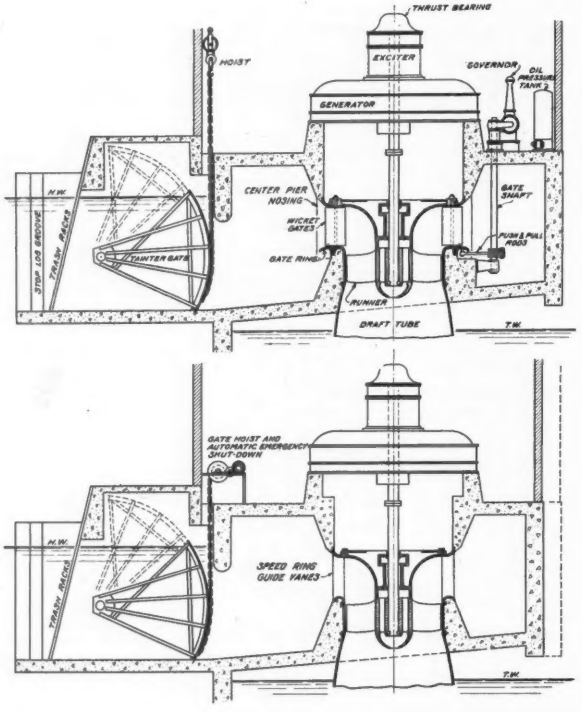


FIG. 3. UPPER SECTION—TYPICAL LOW HEAD SETTING. LOWER SECTION—SAME TURBINE WITHOUT WICKETS OR GOVERNOR

of low or moderate speed, curved and concentric tubes are about equally desirable and efficient; but the preponderance of evidence favors the concentric type for high speed runners, particularly for large capacity developments, although it probably costs somewhat more. However, when one considers the advance made in the past few years in the quantity of water and energy being dissipated through draft tubes of the same gross over-all dimensions, the advance is quite remarkable. As a matter of interest, the accompanying Fig. 2 shows small sections to the same scale of notable installations of relatively low head projects. It is regrettable that the selection of draft tube type still appears to rest rather largely on personal prejudice, uncertain commercial claims and decidedly indefinite efficiencies.

Methods of Plant and Unit Control

Mechanical control of generating units seems to be increasing in favor. By this is meant manual supervision of push-button control whereby starting, synchronizing and similar operations heretofore manually performed are now done mechanically.

Automatic plants, in which the primary decisions are machine made, such as float control for starting and stopping, or voltage control for the same purpose, are continuing to increase in number and favor with the evident expectation that most new small and moderate size installations will eventually be so operated. The saving in operating labor, while present, is perhaps not the greatest or deciding factor but rather the same advantages of mechanical functioning as mentioned above. Human supervision will probably always be desirable in large stations if for no other purpose than for protection of the investment in case of mechanical failures.

Importance of Regulation and Stability

Regulation, governing and stability continue to offer problems for solution, particularly with small installations when tied to large systems at some rather remote point on a transmission network. Under these conditions, much trouble has been experienced with relatively small units, because of their inability to keep in step with the system. System connection introduces severe conditions which in some cases require more regulating constant for absorbing surges and other electrical disturbances not ordinarily felt when operating independently.

As far as regulation on utility load is concerned, a consensus of opinion requires governor control for larger units, but for the smaller units it is agreed that governors might be omitted and the equivalent investment spent for increased regulating constant. This tendency is becoming more definite and leans towards the side of greater output, greater reliability, less mechanical complication and difficulty and less wear and tear on the equipment.

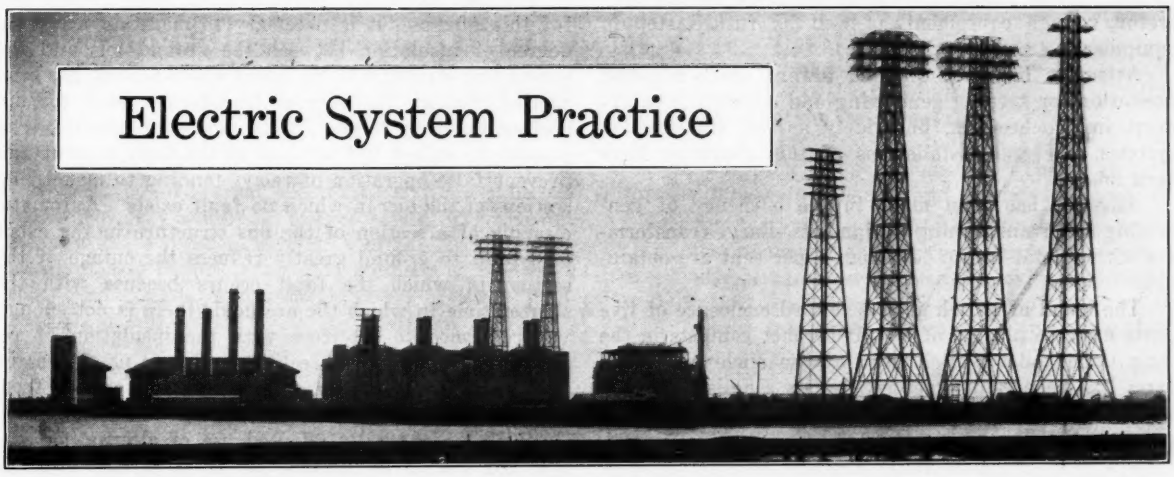
Future Probabilities

If present indications and tendencies are correctly interpreted, some of the developments of the near future will be as follows:

Large capacity peak load hydroelectric plants of adequate pondage and storage will continue to be attractive sources of generation for large systems.

Advantages of interconnected systems are so great that such interconnection and exchange of power will become increasingly common, even though the total exchange of energy is kept practically balanced over any period of time.

For small hydroelectric installations, gateless automatic equipment without governors will become common. The gateless idea is not particularly new, although no units of this kind have as yet been installed but two manufacturers have been studying the details for some time and stand ready to make such installations when requested. By gateless installation is meant a unit without the conventional turbine gates but provided with controlled head gate for cutting off the flow of water to the turbine. The turbine itself could be either propeller or Francis type and should be provided with speed ring to support the generator and fixed vanes for guiding the water onto the wheel. An installation of this nature would have no moving parts except the turbine and its shaft and the head gate, somewhat as shown in Fig. 3.



Large Generators, Improved Methods of Construction, Higher Voltages, Series Capacitors Mark Progress in 1928.

By William McClellan* and H. W. Osgood†

REDUCTION IN costs per kilowatt of generating station capacity and improved economy have been sought for by further increase in the size of the individual generating and transforming units. Outstanding examples of this trend have been the 160,000-kw., single shaft turbo generator unit under construction for a New York City station, and a 75,000-kw., 3-phase transformer unit for Buffalo.

It was only a few years ago that some engineers were expressing the opinion that 200,000 kw. was as much generating capacity as ought to be concentrated in any given location and now we have 160,000 kw. not only in a single unit but on a single shaft. There is no doubt whatever that theoretically, that is from a technical engineering standpoint, this capacity pays and actually reduces the cost to generate electrical energy.

In the minds of some, however, questions have been raised as to its real commercial value, because, if such a unit has any kind of a protracted outage, the idle time is very expensive and the average cost per kilowatt hour of the energy produced may be raised considerably. Such a unit is bound to be, even to the most experienced builders, somewhat of an experiment, involving new ideas in design, and its production by a factory is more in the nature of a construction job than of real manufacturing.

Cost of Operating Large Units

It would be interesting, therefore, to have evidence as to the actual cost of operation including cost of outages of some of the large units of the country in order to determine their actual commercial value. On the whole, in the absence of detailed data the evidence seems to be in their favor.

Such a unit of necessity is of the nature of a base load unit and the possibilities of savings are great. Without attempting to be accurate, the savings in coal alone from operation based upon a 60 per cent load factor could well be upwards of $200,000 a year. In addition to these savings, of course there would be a saving in fixed charges per kilowatt-hour, owing to the reduced cost of the unit per kilowatt of capacity.

A unit of this size is available only in a system where the other installed capacity would be sufficient to take care of the load at any time that this unit was out. A few years ago, there would have been few local situations where these conditions would obtain. Its availability, however, has been enormously increased by the interconnection of systems. Its availability has also been increased by the immense improvement in switching devices, together with the development of divided windings in the generator. So far as the outlook at present is concerned, it is fair to assume that there will be more of these machines installed as time goes on.

With the increase in size of individual generating units, it has been necessary to develop means of reducing the duty on switch gear under short circuit conditions. This has been accomplished by raising the generator terminal voltage, in one instance to 25,000 v., and also by dividing the generator winding into two separate windings each connected to a different section of the bus or transformer equipment; the latter method practically cuts in half the short circuit duty on the switch gear.

Generator Construction

With the design of larger generating units, a skeleton steel frame construction for the generator stator has been developed which makes possible the complete assembling of stator iron and windings at the factory, without exceeding dimensions and weight which it is possible to ship assembled, thus avoiding assembling work which was heretofore done at the station where the unit was installed.

A steam plant is being built in San Francisco which is the counterpart of a steam storage battery, the plant being designed to float on the electric system with the generator operating as a synchronous condenser and in case of a system disturbance, automatically to pick up full load as a generating unit in a few seconds, the boilers being oil fired and only under pilot burners during floating conditions. The switch gear for this

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station will be installed entirely outdoors for all generator voltage equipment as well as future step-up equipment.

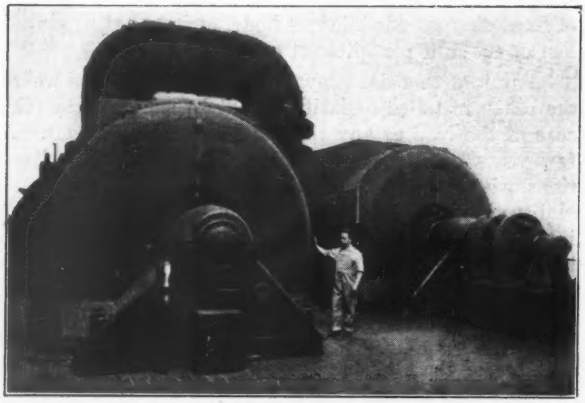
Attention has been directed toward quick response excitation for keeping generating and converting equipment in synchronism, on widely spread transmission systems. Several installations of this character have been made.

Advance has been made in the efficiency of generating and transforming equipment. Large transformers with a total loss of less than 1 per cent are obtainable.

The trend of switch gear is toward enclosure of live parts and the placing of circuit breaker contacts in the tank under oil. Switch gear of the enclosed cubicle type has been supplemented by an English type in which all live parts are enclosed in oil or insulating compound.

Bus Arrangements

When generating equipment of 200,000 kw. or more is concentrated in one station and a considerable part



AMONG THE LARGE GENERATORS PLACED IN SERVICE IN 1928 WAS THIS 160,000-KW. UNIT AT HUDSON AVE.

of the electric distribution from the station is at generator voltage, present practice turns to isolated phase arrangement of buses and switching equipment. The isolated phase arrangement, with the phases arranged either vertically or horizontally with respect to each other, results in a more restricted space about the conductors and equipment of a circuit than in the case of grouped phase arrangement. The effect of this is to provide less space for spread of conducting vapor formed by accidental fault to ground, consequently a greater amount of condensed vapor on insulators.

Experience indicates that it is desirable to insulate buses and conductors against conducting vapor to minimize the change of faults occurring and to prevent spread of trouble due to conducting vapor. To limit the amount of conducting vapor, which is related to the length of time that the arc to ground holds, an automatic means of quickly making dead the section in which a fault occurs has been found desirable. Use has been made of a fault ground bus on which sufficient current is collected from any conductor or switch house equipment which may develop a fault to ground to operate, through current transformers, relays which will act to cut off the section of the bus in fault from its sources of energy.

For the successful operation of a fault ground bus for this purpose, it is necessary to maintain a certain degree of insulation between the ground bus and the supporting structure to the point where the bus has been carried through the current transformer used for operating isolating relays. With moderate expense, it is possible to collect 100 per cent of the fault current and prevent false operation of relays tending to make dead sections of the bus in which no fault exists. Automatic clearing of a section of the bus structure in the event of a fault to ground greatly reduces the outage of the section in which the fault occurs because with the shorter time in which the arc holds there is not enough vapor formed to interfere with the insulation of remaining circuits in the sections and it is not necessary to wipe off the insulators before resuming service from the section.

With the generally adopted use of alternating current for station auxiliaries, air break circuit breakers have been used to some extent for auxiliary motors of 550 v. and less, where conditions will permit. With this development have come means for quickly breaking the arc on the circuit breaker contacts.

Studies of causes of failure of switch gear indicate that the majority of cases are due to mechanical failures of the breaker parts or operating gear. In this respect, switch gear would profit by greater care on the part of the manufacturer in the design of switch gear parts.

The number of types of circuit breakers offered by individual manufacturers could well be reduced with a resulting economy in production for the manufacturer and in station design for the operator—some progress has been made in this respect, but there is a field for additional effort in this line.

Transmission Line Practice

There has been further increase in the mileage of 220-kv. transmission lines in the East. Attention has been directed to reduction in trouble due to vibration of conductors and means of protection against induced voltages. Conviction has been strengthened that the use of overhead ground wires is effective to prevent flashovers; further intensive studies have been made of the induced voltages attained in actual transmission lines by use of the klydonograph.

Use has been made of series capacitors in transmission circuits of moderate voltage to neutralize the effect of reactance and thus bring the voltage drop nearer a function of the resistance drop of the line. This offers a means of increasing the amount of power that can be transmitted over a line with low operating loss and without impairment of circuit reliability.

Further experience with operation of 66, 75 and 132-kv. single conductor cables has demonstrated their practical reliability and in the case of the latter voltage oil filled cables have been quite satisfactory. With the development of single conductor cables up to 75 kv. for conductor sizes of 1,250,000 c.m. and the conductors arranged in the ducts for reduction in sheath losses, circuit transmitting capacity up to 100,000 kv-a. is possible.

Improvements made in cable insulation and methods of manufacture during the last 5 yr. have greatly reduced the number of cable failures, thereby increasing the reliability of cable distribution up to 33 kv.

Electric Equipment in the Boiler Room

GREATER APPLICATION OF ELECTRICAL EQUIPMENT IN BOILER ROOM PERMITS MORE CENTRALIZED CONTROL AND GREATER FLEXIBILITY IN OPERATION

IN THE BOILER room as in all other parts of the modern power station, electricity is rapidly becoming the primary source of motive power. This is due not only to the inherent simplicity of the electric motor drive but also because extraction methods of feedwater heating have made unnecessary the use of large quantities of exhaust steam from steam driven auxiliaries to maintain the proper heat balance. Before the general adoption of stage feedwater heating or the use of steam driven auxiliary turbine unit, it was necessary to use steam driven auxiliaries in order to obtain sufficient exhaust steam for heating feedwater. Today other methods of obtaining heat balance give the electric motor unlimited opportunity to demonstrate its suitability for any type of drive, purely on its own merits.

This does not imply that the electric motor is for all drives to be preferred to engines or turbines, for to convey such an impression would be unjust. There are a number of purposes for which steam driven equipment has advantages over the electric motor and, in such instances, steam drives should be used. Furthermore the use of a certain number of steam driven auxiliaries for emergency service is an excellent method of insuring against shutdown.

Electricity is used for other purpose in the boiler room besides that of operating auxiliaries. As a means of controlling and operating steam driven equipment, it has become exceedingly popular. The motor operated valve, controlled from a remote point, for instance, is one application of electric control that has contributed greatly toward betterment of operating conditions.

Today, the centralized boiler control board is an important feature in every large plant and may be seen in many small ones. In addition to the necessary pressure, temperature and draft gages and recorders mounted on these boards will be found the push-button control switches for the motor-driven auxiliaries in the plant.

In pulverized coal plants, it is of great importance that all the elements which make up a pulverized fuel burning system be stopped and started in the proper sequence. Electric control furnishes an excellent means of attaining this requirement, due to the almost unlimited possibilities of the electric relay.

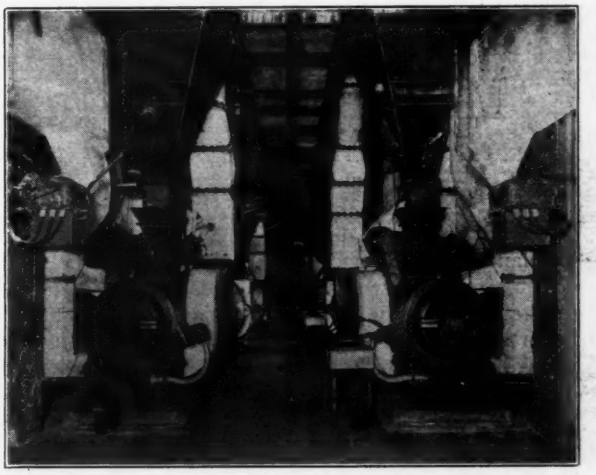
At the plant of the A. E. Staley Co., a control system incorporating these features was placed in service this year when their new steam generator was installed. This control is entirely foolproof, the relays being so set and so interlocked as to prevent any of the motors being stopped or started except in their proper order and at the proper time with respect to each other.

No part of the system can be started unless the forced and induced draft motors are operating. Once these are placed in operation by means of the push button on the control panel, the other motors driving the mills and exhausters can be started in the proper sequence. When shutting down, the mill motors stop first, followed by the exhaust fans 30 sec. later; finally, the forced and induced draft fan motors stop 2 min. after the stopping of the exhausters. This is done to clear the furnace of all coal and combustible gases.

This application of relays to coordinate the control of a number of motors on a single system also is used in connection coal handling systems in stoker fired plants.

USE OF INDUCTION MOTOR PREDOMINATES

As may be noted from the data on the various plants contained in this issue, the induction motor finds strong favor for many applications in the boiler room. For the driving of forced draft fans, its use in several modified forms is almost universal. Induced draft practice also makes great use of the induction motor but in this case the steam turbine is occasionally used.



A VIEW IN THE BOILER ROOM AT CAHOKIA, SHOWING THE APPLICATION OF MOTORS TO PULVERIZING UNITS

Draft fan service demands a motor which permits of some variation in speed, hence the ordinary squirrel cage motor is not ordinarily suitable. The simple squirrel cage motor is a constant speed motor and while it is perhaps the simplest and most reliable of all motors it is not adopted for service requiring speed variation.

For forced and induced draft service, in power plants, the so-called slip ring or wound rotor type of induction motor with external resistances seems to be preferred. The multispeed induction motor, however, is also well adapted for this class of service and it will be noted that many plants use it. This type of motor is designed to run at two or more constant speeds. Neither resistance nor reactance is used, the various speeds being obtained by a controller which effects changes in the polar grouping of the stator coils. It is available either as a constant torque multispeed motor or as a constant horsepower multispeed motor. The former type, which will develop constant torque at any of the different speeds, the horsepower output being proportional to the speed, is the type generally used for draft fans because in such equipment the power required decreases with the speed.

Another type of motor used for forced draft service although far less frequently than the two types described, is the a.c. commutator type motor. This type, used at Long Beach Station No. 3, has a commutator and the speed is varied by shifting the brushes. It is more efficient at low speeds than slip ring motors and any number of speeds can be obtained.

Stoker Drives

For driving underfeed or chain grate stokers, both alternating- and direct-current motors are used. The direct-current motor of course is well adapted for this class of drive because of its excellent speed variation characteristics, but because of the absence of direct current in most of the new power plants its use is limited. As will be noted, the direct-current motor is used for stoker drive at Edgar, Hudson Ave. and Toronto stations.

Where alternating current motors are used for stoker drive, the multispeed motor seems to hold favor, as it is used in a number of the newer plants. Since this type of motor does not provide for intermediate speeds between those for which it is designed to operate, selective gear shifts are often used which greatly increase its flexibility of application.

In pulverized coal burning stations, as in those which are stoker fired, the electric motor is used almost exclusively for driving the coal handling and preparation equipment. The variable speed induction motor for mill drive is common, as it has the necessary speed variation characteristics demanded by this service. Control is from a centralized control panel in the boiler room through the usual systems of push-button control.

For driving boiler feed pumps and other pumps, in the boiler room, where motors are used, the squirrel cage or wound rotor motor is used, depending upon whether a constant or varying speed is desired. Requirements for this service are not greatly different from those demanded by any centrifugal pump drives and the selection of motors depends largely upon the pump characteristics.

Modern Practice in Electric Station Design

Effect of High Voltage Transmission, New Excitation Systems, Practice in Providing Insulation, Relays and Metering. By H. C. Sutton*

TENDENCIES in the mechanical design of power plants have had a distinct bearing on the electrical design of our power systems. The use of large generating stations with the higher efficiencies has advanced the importance of the transmission at higher and higher voltages, until now large metropolitan areas no longer distribute the bulk of the power at generator voltage. Our kite is tied to transmission. Many cities are supplied by an outer belt or transmission ring, a number of step-down substations taking energy from the ring. The establishment of preferred standards by the Joint Committee of the N. E. L. A. and the N. E. M. A. should be helpful in the selection of voltages in the design of new power systems.

Station Service

With the use of large generating units, the overall efficiency of the station has been greatly increased by the use of higher boiler pressures, induced and forced draft air preheaters, economizers, and powdered fuel, etc., so that the central station now finds itself its own largest customer in the substation to supply the electrical station auxiliaries. For instance, a station now being built of 130,000 kw. initial capacity requires 22,000 hp. for motor driven auxiliaries. In this installation, powdered fuel and 1400 lb. boiler pressure are the important factors in the number and size of the motors used.

There is a tendency toward the use of unit system for station service supply in some cases, the generator lead being tapped for the station auxiliary transformers of sufficient capacity to take care of the auxiliaries for one generating unit, emergency supply being taken care of by an additional step-down bank from the high tension bus to the bus to be used in emergency as a reserve for any main station auxiliary transformers.

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In several stations of medium capacity, it has been found economical to supply all station auxiliaries at 440 or 550 v. Moreover, where 2300 v. are used for the supply, or the larger motors, there has been a saving in using 550 v. for motors less than 150 hp. in capacity. The lower voltage is advantageous in that the air circuit breaker is used. This type of switchboard and control can be installed at any convenient location, without the usual precaution and expense incident to the 2300-v. supply, where oil circuit breakers are required.

A few years ago, the first high tension generating station was built at Devon, Connecticut, where transformer banks are used as part of the generator lead, so that in effect generation is at transmission voltage. There are now quite a number of this type of station. The principal advantage is the elimination of the indoor switching equipment, the switch house, and of the so-called isolated phase arrangement, where it has been found difficult to isolate the trouble during short circuits.

Excitation System

In one station now under construction, a sub-exciter is mounted on the main generator shaft beyond the main shaft end exciter. This sub-exciter is used to excite the field of the main generator exciter. The use of the sub-exciter increases the stability of the unit by speeding up the excitation, and at the same time it eliminates the main generator rheostat. Other stations have been built with quick response excitation systems by using motor generator sets of special characteristics, to increase the stability of the interconnected systems, particularly where long distance transmission is used.

Forced air cooling has been used with success to increase the capacity of existing transformers. This type of cooling works out particularly well in certain substation designs. This is exemplified by a substation

built this year to tie together the system of The Philadelphia Electric Company and Philadelphia Suburban-Counties Gas & Electric Company at 66 kv. Duplicate lines and transformer banks were used at the receiving end, each line and bank having the full tie capacity of 45,000 kv-a. The lines were paralleled on the 33 kv. low tension side of the transformer banks only. Ordinarily, the load is divided between the two banks and the forced air cooling is not necessary. Forced air cooling will only be used when one line and transformer bank are out of service.

A number of substations have been built recently where the high tension bus is omitted. The substation is supplied by duplicate lines and transformer banks. Increased load on the substation of approximately 50 per cent will be provided by the future installation of forced air cooling on the existing banks.

There is an increased use of changing transformer taps under load. This type of transformer has been used particularly in tying together power systems where the energy flow reversed periodically.

Generator Leads

Due to the great capacity of the generator, the main generator lead presents a difficult problem. In some cases a number of large single conductors are used. Bronze tape has been used on the outside instead of lead, to reduce the sheath currents. In a number of modern stations this problem has been solved by using bare copper bus mounted in cells under the floor. The generator lead is run as open bus under the floor, and through the station wall to the transformer located outdoors, adjacent to the generator room. In some stations, an extra precaution is taken in covering this copper tube with varnished cambric insulation or enclosing the bare lead in rat proof compartments.

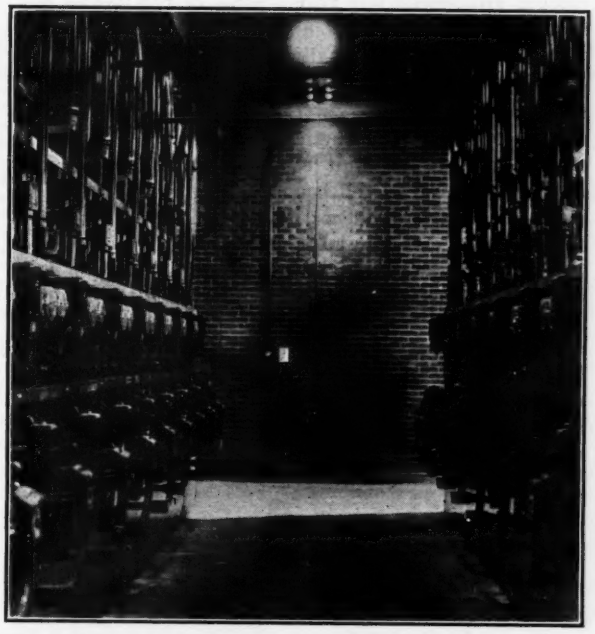
Line vs. Substation Insulation

Transmission lines are generally insulated at higher and higher values. It becomes increasingly difficult to coördinate the substation insulating values with that of the transmission line. Higher insulation on transmission lines has reduced the number of outages on the lines during lightning storms. This practice, however, will place a greater burden on the substation equipment with possibly more frequent trouble from transformer burn-outs, unless the transformers of higher insulating values are purchased. The trend in some larger systems is to purchase transformers, oil circuit breakers, and other electrical substation equipment of a class higher than the normal voltage rating.

In a large station now under construction, it is proposed to increase the insulation between coils and coil groups in the transformer, and to locate the lightning arrester stack immediately adjacent to each single-phase large power transformer. In this particular installation the impulse rating of the line insulation is higher than the impulse rating of the standard transformer.

The trend of relaying is to speed up the whole system of protection, so as to isolate the trouble in the shortest time interval, thereby reducing the damage to the system and apparatus during short circuit and grounds. The use of the second line of defense in relay protection is increasing in plants of large capacity. Such a second line of defense is obtained where practicable by having the second line relays trip breakers in emergency, other than those tripped by the normal protection.

Bus differential protection is increasing in use for clearing bus faults. Generator and transformer differential relay protection has increased in use, as evidenced by the use of differential protection between halves of generator windings, where the two portions of the generator winding are connected in parallel.



TYPICAL RELAY AND SWITCHING INSTALLATION IN A MODERN POWER PLANT

Protection to the electrically driven auxiliaries in power stations is being given special study. The trend is to protect for short circuits but not for overload, due to the importance of the electric drive in power plant operation.

Some systems have greatly simplified the metering by eliminating all meters, except to measure the generated and purchased output and the customers' consumption. The expense incident to metering transmission, substation and distribution losses separately is saved.

Switchboards

The trend in switchboard design is towards compactness. This is obtained by providing separate relay panels, the use of bench board for control and additional panel boards for the metering. A more recent development is the use of miniature control, where the switchboard is reduced in space so that a single operator has within his reach the control of a large generating station.

No man is bound to be rich or great; no, nor to be wise; but every man is bound to be honest.—Sir. Benj. Rudyard.

Generator Progress Shown by Large Units

SINGLE GENERATOR OF 100,000 KV-A. CAPACITY, INSTALLED AT LONG BEACH STATION, ONE OF THE OUTSTANDING ACHIEVEMENTS OF THE YEAR

EQUIPMENT USED in the generation of electricity this year was not marked by any startlingly new developments although refinements in many directions contributed to increase the overall efficiency and reliability of the station. This year, the work of the manufacturers was concerned largely with the execution of designs announced last year. Some of the largest generators ever built were completed and placed in service this year, and other smaller units incorporating new methods of construction and higher voltages are under construction.

In generator construction, the practice of building and assembling the unit complete at the factory and shipping it fully wound has been adopted by the larger manufacturers and seems to be working out satisfactorily. There are a number of advantages to be gained by this practice. First, a manufacturer desires to build a unit complete in his own shops because the building is done under shop conditions which are a closer approach to ideal manufacturing conditions than can be obtained in most power plants and affords complete control of the processes necessary to successful construction. Secondly, it gives the manufacturer an opportunity to conduct tests which will ultimately result in advances in the engineering art.

LIMIT IN SIZE NOT YET REACHED

As the size of units, there seems to be no difficulty on the part of the manufacturers in building generators to accommodate the largest steam turbine units that can be used. So far, however, the largest unit that has been built and placed in service is the 100,000-kv-a. generator at Long Beach Steam Plant No. 3 of the Southern California Edison Co. This unit is of welded plate construction throughout and is one of the first units placed in operation in this country at a voltage considerably higher than the usual high limit of 14,000 voltage. The long beach unit is designed for 16,500 v., 50 cycles.

Reference to the accompanying table showing the capacities of the different generators, will show that there is at least one generator listed which is larger than the 100,000-kv-a. machine at Long Beach. At Hudson Ave., for instance, a 110,000-kw. machine is referred to. While, as far as purely electrical operation is concerned, this is one machine, mechanically it is not as it consists of a cross compound turbine driving two separate generators, each having about half the capacity of the entire unit. The generators are solidly tied together and to an autotransformer stepping the voltage up to 27,600 v. with switching on the high tension side. The neutral points of both generators and auto transformers are solidly grounded. The unit is started with field on both generators, the low-pressure element starting as a motor.

At Hell Gate, it will be noted, two new turbine-generating units are listed. One of these is a Westinghouse unit consisting of a cross compound turbine connected to two 94,200-kv-a. generators. The other is a Brown Boveri Co. unit made in Switzerland and consisting of a cross compound turbine, the high-pressure element driving on 88,250-kv-a. generator and the low pressure, a 100,000-kv.a. generator. This latter unit is now being installed and will soon be placed in operation. The low-pressure element of the Brown Boveri unit at Hell Gate and the new machine at Long Beach, are the two largest generators thus far constructed.

Another notable generating unit is the 104,000-kw. machine at the Crawford Ave. Station of the Commonwealth Edison Co. in Chicago. This machine, installation of which has just been completed, consists of a cross compound turbine, comprising a high-pressure element, an intermediate low-pressure element and a low-pressure element, driving two separate generators. The high-pressure element is direct connected to a 44,000-kw., 85 per cent power factor generator and the intermediate low-pressure and the low-pressure turbines arranged in tandem, drive a 56,000-kw. generator.

METHODS OF CONSTRUCTING LARGE UNITS

These generators are made with the skeletonized frame type of construction, each frame being split into two sections at right angles to the longitudinal axis of the generator. The function of the frame in machines of this type are reduced to that of merely supporting and guiding the stator laminations. Lifting of the complete stator is accomplished by means of removable trunnions which are detached when the sheet steel superstructure is built in place. The feet on which the station ordinarily rests on the foundations are made removable so that railway clearances are as large as possible in the larger size generators.

Stator laminations are punched from low loss sheet steel, and insulated through bolts under tension between end plates and non-magnetic finger plates make the core self-sustaining and homogenous.

Coils of the stator winding are of the diamond type made in halves. It is expedient to use half coils from a manufacturing view point because complete coils, because of their weight, become difficult to handle. The weight of a whole coil for a 56,000-kw. generator is approximately 300 lb.

Using the skeleton frame type of construction, stators for single shaft units of 100,000 kv-a. at 1800 r.p.m. can be built and wound complete at the manufacturers works and shipped ready to be placed on the customers foundations.

Thus far in this article, we have considered only the largest units. In considering the smaller units placed in operation in central stations during the year, with a few exceptions, 35,000 kv-a. seems to be about the lower limit. In the case of Vienna Station, 7500-kw. units are installed because of the very limited load available in the section it serves. At Edgar, it will be noted, a 12,500-kv-a. machine is installed, but this size was fixed by the capacity of the 1200 lb. pressure turbine.

In industrial plant installations, the size of generating units is of course very much smaller. Depending upon the type of industry and the size of plant served, generators in industrial plants will vary between 1000 and 10,000 kw. For capacities below 1000 kw. the engine-driven generator is more common than the turbine-driven type.

Generator Voltage

Generator voltages this year, with one or two exceptions to be noted, have not varied greatly from that which has been standard for several years, i.e., 12,000-14,000 v. For machines of ordinary capacities, this voltage seems satisfactory. For the large units now being built, however, it seems that a higher voltage is to be desired because of the enormous currents involved and the consequent heavy copper. By generating at 22,000 v., the size of copper used in a machine of given capacity can be greatly reduced, not only facilitating construction but making possible more effective insulation.

At least two stations will use generators of this voltage. One unit is already in operation at the Powerton Station of the Super-Power Co. of Illinois, and two others are being built for the State Line Station. The latter are the 208,000-kw. units announced last year. The 16,500-v. generator at Long Beach has already been mentioned.

Sixty Cycles Most Common

With the exception of Long Beach and Gould St. Stations, all of the central stations listed in this analysis generate current at a frequency of 60 cycles per sec. Long Beach, with a 1500-r.p.m. generator, generates at 50 cycles while Gould St. uses 62½ cycles. The reason for this odd frequency is undoubtedly to provide a more suitable ratio between the Baltimore system frequency and the hydroelectric system frequency to which it is tied. The 43,750-kv-a. units at Gould St., although operating at present at 62½ cycles, are designed to operate later at 60 cycles.

ELECTRIC GENERATOR PRACTICE

NAME OF STATION	MAIN GENERATING UNITS							HOUSE SUPPLY		
	CAPACITY	SPEED	VOLTAGE	VOLTAGE REGULATION	EXCITER	COOLING TYPE SYSTEM	COOLING TYPE COOLER	METHOD	ALTERNATIVE METHOD	VOLTAGE
PHILO 1928 EXTENSION	3-62,353 KV.A.	1800	11,000	AUTOMATIC OR MANUAL	SHAFT TYPE	CLOSED	FIN TUBE	HOUSE ALTERNATOR 2-3000 KW.	TRANSFORMERS FROM TRANSMISSION LINES	2300 V.
CAHOKIA 3RD SECTION	1-55,556 KV.A.	1800	13,800	MANUAL	SHAFT TYPE	CLOSED	CONDENSATE THROUGH FIN TUBE	HOUSE TURBO ALTERNATOR 2-2000 KW. SERVING WHOLE STATION	TRANSF. FROM OUTSIDE TRANSMISSION LINES	2300 V.
VIENNA, MD. STATION	2-7500 KV.A.	3600	6600	AUTOMATIC	SHAFT TYPE	CLOSED	U-FIN	FROM GENERATOR LEADS THROUGH TRANSF.	HOUSE GENERATOR	440 V.
LONG BEACH NO. 3	1-100,000 KV.A. AT 0.9 P.F.	1500	16,500	AUTOMATIC	MOTOR DRIVEN	CLOSED	FIN TUBE	SHAFT DRIVEN 5000 KV.A.	QUICK STARTING AUX. TURBINE GENERATOR RATED 3125 KV.A.	2300 V.
KEARNY 1928 ADDITION	NO NEW GENERATING EQUIPMENT INSTALLED									
BINGHAMTON 1928 EXTENSION	1-35,000 KV.A.	1800	13,800	MANUAL	SHAFT TYPE	CLOSED	FIN TUBE	HOUSE TRANSFORMER	TRANSF. FROM OUTSIDE TRANSMISSION LINES	2300 V + 220 V.
HELL GATE 1928 EXTENSION	2-99,000 " 1-66,250 " 1-100,000 "	1800 " 1200	13,800	MANUAL	SHAFT TYPE	CLOSED	EXTENDED SURFACE	SHAFT DRIVEN HOUSE ALTERNATOR - 5000 KW.	TRANSFORMERS FROM STATION BUS	2300 V.
SAGINAW RIVER 1928 EXTENSION	1-37,500 KV.A.	1800	12,000	MANUAL	SHAFT TYPE	CLOSED	FIN TUBE	HOUSE TURBINE 3500 KW.	DUPLICATE BANKS OF TRANSFORMERS FROM OUTSIDE LINES	440 V.
STATION C P.G. & E. CO. 1928 EXT.	1-37,500 KV.A.	1800	12,000	MANUAL	SHAFT TYPE	CLOSED	FIN TUBE	AUX. TRANSF. BANK CONNECTED TO MAIN STATION BUS		2300 V.
HORSESHOE LAKE STA. 1928 EXT.	1-37,500 KV.A.	1800	13,200	AUTOMATIC	SEPARATE DUAL DRIVE	CLOSED	FIN TUBE	13.2/2.3 KV. TRANSF. ON 13.2 KV. BUS OF GENERATORS NO. 1 + 2	DUPLICATE TRANSF. BANKS WITH INTER CONNECTIONS	2300 V.
EDGAR 1928 EXT.	1-75,000 KV.A. 1-12,500 KV.A.	1800 3600	14,000 "	MANUAL "	M.G EXCITERS + EXC. BUS "	CLOSED "	SPECIAL FIN TUBE "	6250 KV.A. AUX. SHAFT GENERATOR	TRANSF FROM 14,000 V. BUS TRANSMISSION LINES + OTHER TURB.	2300 V.
HUDSON AV. 1928 EXT.	1-110,000	1800	13,800	MANUAL	SHAFT TYPE	CLOSED	FIN TUBE	TERTIARY WINDINGS FOR TURBINE AND BOILER AUX.	HOUSE TRANSF. FED FROM MAIN STATION BUS AND OUTSIDE STATIONS	2300 V.
GOULD ST.	2-43,750 62½ CYCLES	1875	13,200		1-SHAFT 1-TURB. DRIVEN EMERG.	CLOSED	5-COND. SECT. 5-HARBOR W. SECTION	1,500 KV.A. AUX. GEN. ON MAIN UNIT	TRANSFORMERS	460 V.
TORONTO 1928 EXT.	1-37,500	1800	11,500	AUTOMATIC	SHAFT	CLOSED	FIN TUBE	HOUSE GENERATOR	TRANSF.	2300 V.
TRINIDAD	2-25,000	1800	12,500	AUTOMATIC	SHAFT	CLOSED	FIN TUBE	FROM GEN THROUGH TRANSF. TO AUX. BUS	HOUSE TURB. - 1200 KW. 2300 V. OR THROUGH TRANSFORMER FROM 60 KV. BUS	2300 V.
CRAWFORD 1928 EXT. UNIT NO. 5	HP-38825 LP-64,705 AUX-4566	1800 1200 1800	12000 12000 2300	MANUAL	SHAFT	CLOSED	FIN TUBES	DIRECT CONNECTED 3500 KW.	TRANSF.	2300 V.
UNIT NO. 6	HP-52940 LP-64,700 AUX-5715	1800 1800 1800	12,600 12,600 2300	MANUAL	SHAFT	CLOSED	FIN TUBES	DIRECT CONNECTED 4000 KW.	TRANSF.	2300V
LAKE PAULINE	1-18,750	1800	13,800	AUTOMATIC	SHAFT	CLOSED	FIN TUBES	3 ϕ 1500 KV.A. TRANSF. CONNECTED TO 13.2 KV. BUS	3 ϕ 1500 KV.A. SPARE TRANSF. CONNECTED TO 13.2 KV. BUS	2300 V.
U. S. RUBBER CO.	2-6250 1-3750 1-4000	3600 " "	2300 2300 440	AUTOMATIC	SEPARATE BUS " SHAFT TYPE	CLOSED " "	U-FIN " "		TRANSFORMERS	2300 + 440 V.
ACHESON HARDEN	1-250 KW. 3-75 " †	200 275	230 D.C.	MANUAL		OPEN		10 KW. TURBO-GEN.	PUBLIC SERVICE CO.	230 V.
PISTON RING CO.	1-1250 KV.A.	150	480	AUTOMATIC	CHAIN DRIVE FROM MAIN UNIT					480 V.
ANGLO-CANADIAN	1-7500 KV.A AT 100% P.F.	3600	2200	AUTOMATIC	SHAFT	ATMOSPHERIC AIR THROUGH AIR FILTER				
SORG PAPER CO.	2-5000 KV.A.	3600	6600	AUTOMATIC	DUAL DRIVE	CLOSED	SPECIAL FIN TUBE	HYDRO PLANT	TRANSFORMERS	440 V.
STANOLIND	3-5000 KW. 0.8 P.F.	3600	2300	AUTOMATIC	INDEPENDENT M.G. SET	CLOSED	FIN TUBE	FROM MAIN BUS AND AUX. GENERATOR 2-1000 KW. AUX. UNITS 1-1250 KW. " "	NORMALLY THE AUX. GEN. PRODUCE ONLY A PORTION OF AUX. POWER SINCE THEIR LOAD IS DEPENDENT UPON STEAM REQUIRED FOR F.W. HEATS.	2300 V.

† - OLD EMERGENCY UNITS

Voltage Regulation

As pointed out in our 1927 analysis, voltage regulation in stations supplying large metropolitan areas, is in most cases effected by manual control, while stations serving long transmission lines or scattered areas tend toward automatic voltage regulation of generators. This is due to the fact that in the former class of station

the individual feeders are each equipped with automatic voltage regulators, which regulate the voltage at the load, regardless of the voltage at the generator. Stations, such as Philo, Vienna and Horseshoe Lake, however, which supply distant loads through long transmission lines, require more accurate voltage control at the generators in order to keep the transmission voltage constant.

Ventilation of Generators

That the closed system of generator ventilation has proved a success or at least found favor, is evident from the accompanying tabulation. This method of cooling has become standard as has also the fin tube type of cooler. The closed system not only provides a positive means of abstracting the heat produced in the windings but also serves as a protection against destruction by fire, by limiting the oxygen supply in case of fire.

Of particular interest in connection with this question of generator ventilation, is the use of hydrogen for cooling in a synchronous condenser recently installed at Pawtucket, R. I. In our 1927 analysis, it may be recalled, this method of cooling was discussed although at that time no commercial application had been made. While it has not yet been applied to generators, the use of hydrogen as a cooling medium in this synchronous condenser would indicate that its use in generators would be successful.

The machine at Pawtucket which was described in a recent issue* is installed outdoors. If the condenser were air cooled, its capacity would be 10,000 kv-a. but by having it hydrogen cooled, its capacity has been increased to 12,500 kv-a. With hydrogen at 15 lb. pressure, the machine can deliver 15,000 kv-a. without exceeding the normal temperature guarantees.

House Supply

In the matter of a source of current for supplying the station auxiliaries, there seems to be no definite practice, although the shaft type auxiliary generator direct connected to the main unit is being used to a greater extent in large stations. This method has the advantage of an isolated source of supply, at the same time having the economy of the main turbine units.

Electric Switching and Transmission

Bus Arrangement, Protective Features, Grounding Practice Methods of Bus Construction, Transformer Practice

JUDGING FROM the single-line diagrams of electrical systems contained in the accompanying table, from a casual examination, at least, it would not seem that there was anything pertaining to uniformity about them. There seem to be as many different arrangements as there are systems.

Despite this apparent lack of uniformity, however, a closer study of the diagrams will show that although they may differ according to local requirements, they are all based on certain broad fundamental principles. In this respect, too, as was the case with the question of voltage regulation discussed in the preceding article, the stations lend themselves to classification according to whether they supply nearby metropolitan areas or whether their output must pass over long transmission lines to distant points of distribution. In stations of the former class, the generators are usually connected directly to the main buses which operate at or near generator voltage. In stations supplying distant loads, transformers are usually interposed between the generator and the main bus which step the voltage up to a value considerably greater than generator voltage.

Methods of actual construction vary widely, both in regard to the design of equipment and its arrangement in the switch house, although here too classification is possible. In general, it seems that generating stations having an expected ultimate capacity of 200,000 kw. or more are being constructed with the isolated phase type of switch house, while in those below that capacity adjacent phase grouping is more common. The opinion seems to prevail, but is not unanimous, that a greater degree of protection is afforded by the isolated phase system in large stations than is possible with phase grouping.

Of 24 stations described in a recent report of the electrical apparatus committee of the N. E. L. A., 12 are designed for an ultimate capacity of not less than 200,000 kw. and of these, 11 have isolated phase layouts. The one exception is a station in which the principal switching is done at high voltage on an outdoor structure. In all but four of the stations of less than 200,000-kw. ultimate capacity, the adjacent phase arrangement has been employed.

In stations of large size, it seems to have been pretty generally conceded that the space required for a phase isolation layout is little, if any, more than required for the adjacent phase design, and that there is an additional security afforded by the isolated phase plan which justifies any additional cost.

Most of the isolated phase stations employ the vertically isolated system rather than the horizontal method of isolation. Of the 15 isolated phase switch houses listed in the N. E. L. A. report on bus and switch structure design, only four employ horizontal separation.

Due to the fact that many of the manufacturers of oil circuit breakers have provided facilities for the testing of oil switches, the oil circuit breaker situation seems to be reaching a stage of more definite determination. Few cases have arisen when the equipment was not capable of interrupting short circuit currents up to the limits specified by the manufacturer.

Reference to the accompanying table will show that there is little uniformity among the types of oil circuit breakers used in the various stations. Both the motor and solenoid operated types are used, the type selected for any particular installation varying, no doubt, with the individual preferences of the designers and with the exact local requirements.

In the matter of connecting the generator to the buses, it will be noticed that at least two stations, Hudson

*Power Plant Engineering, Nov. 1, 1928. Page 1169.

Avenue and Saginaw River, do this through the agency of auto transformers. These are connected as shown in the single-line diagrams and serve to step the voltage up to 27,600 in the case of Hudson Ave. and 22,000 at Saginaw River.

The use of the differential relay scheme of protection against generators from the effects of internal failure seems to be almost universal. It is used either alone or in combination with some other method in all of the central stations listed. The differential scheme is simple and effective under most conditions of trouble. It has some limitations, such as failure to protect against open circuits and short-circuited turns, but these types of failure are remote and the failure of the differential system to guard against them is no serious detriment to its general adoption.

Where it is desired to guard against the effects of open circuit and short-circuited turns, a combination of split conductor and the current differential system is sometimes used. This method, used on the 100,000-kv-a. generator just installed at the Long Beach Steam Plant, can only be applied to machines of recent design where the conductors are connected in two or more parallel paths.

In some cases, at Edgar and at Long Beach, the differential relays not only trip the field, main, neutral and auxiliary generator circuit breakers, but also release the CO_2 gas to the cooling chamber.

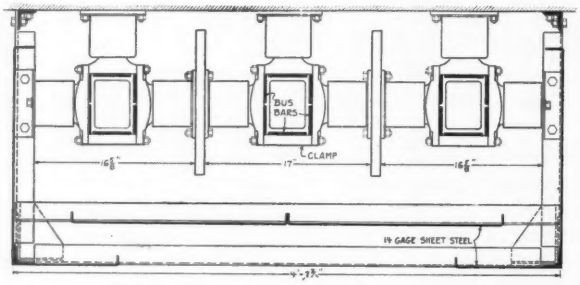
ELECTRIC SYSTEM DATA

NAME OF STATION	BUS AND SWITCHING SYSTEM: SINGLE LINE DIAGRAM, GEN TO BUS	BUS AND SWITCHING SYSTEM: TYPE & VOLT. OF OIL C.B.	BUS SYSTEM: TYPE	BUS SYSTEM: VOLTAGE	PROTECTIVE FEATURES: REACTORS	PROTECTIVE FEATURES: RELAYS	PROTECTIVE FEATURES: GROUND	TRANSFORMERS: TYPE	TRANSFORMERS: PURPOSE	TRANSFORMERS: CAPACITY	TRANSFORMERS: WINDING CONNECTION	TRANSFORMERS: POTENTIAL CHANGE
PHILO 1928 EXTENSION		FLOOR TYPE, OUTDOOR SERVICE. 132,000 V. 600 AMP. MOTOR OPERATED	HORIZONTAL NOT ISOLATED	132,000	NO REACTORS	GENERATOR DIFFERENTIAL RELAY TRANSFORMER DIFFERENTIAL RELAY GEN. NEUTRAL RELAY	NEUTRAL GROUND 2 OHM RESISTOR O.C.B. NORMALLY OPEN	G E TYPE W C	MAIN POWER	3 BANKS OF 3 EACH 21,000 KV.A.	Δ-Y GROUNDED NEUTRAL ON CENTER BANK ISOLATED NEUT. OTHER 2 BANKS	11/132 KV.
CAHOKIA 3RD SECTION		13 KV. INDOOR TRUCK TYPE MOTOR OPERATED	VERTICAL ISOLATED PHASE	13,800	BUS REACTANCE 5% ON 84,759 KV.A.	DIFFERENTIAL RELAY PROTECTION ON MAIN GENERATORS	3 OHM, ONE MACHINE AT A TIME	OISC+ OI WATER CIRCULATION 3 PHASES	MAIN POWER	7,500 12,000 50,000	Δ-Y Δ-Y Δ-Z	13.8/33 13.8/66 13.8/115 KV.
VIENNA, MD. STATION		50 KV. OUTDOOR SOLENOID OPERATED	OUTDOOR	22 KV. PRESENT 44 KV. FUTURE	NONE	DIFF. {GENERATORS TRANSF. OVERLOAD & GROUND ON FEEDERS—	NEUTRAL GROUNDED THROUGH 48 OHM RESISTOR	ALL OISC	MAIN POWER	2 BANKS 3-2500 KV.A. 1 SPARE	Δ-Y	6.6/22/44 KV
LONG BEACH NO. 3		A-25 KV. MOTOR OPERATED B-220 KV. SOLENOID OPERATED	OUTDOOR 4" IRON PIPE HORIZONTAL ARRANGEMENT	220 KV.		OVERALL DIFFERENTIAL & SPLIT CONDUCTOR DIFF RELAYS ON MAIN GENERATORS	SOLID GROUND ON GEN. & 22 KV. SIDE OF TRANSF.	OISC WITH AIR BLOWERS TO OPERATE ABOVE 60% RATING	MAIN POWER	3 33,333 KV.A UNITS	Δ-Y	16.5/220 KV
KEARNY 1928 EXTENSION			— NO. NEW ELECTRICAL EQUIPMENT INSTALLED —									
BINGHAMTON 1928 EXTENSION		NEUTRAL + MAIN — 15 KV. OUTDOOR TYPE ELECTRICALLY OPERATED	NO LOW TENSION BUS USED	13.2 KV.	NONE	DIFFERENTIAL RELAY PROTECTION ON MAIN GENERATORS + TRANSF.	GEN. NEUTRAL GROUNDED SOLID THROUGH O.C.B. N.T. SOLID	OISCR	MAIN POWER	35,295	ΔΔY	13.2/33/119 KV.
HELL GATE 1928 EXTENSION		15 KV. TYPE 044 INDOOR, SOLENOID OPERATED	HORIZONTAL ISOLATED PHASE	13.8 KV.	5% IN GENERATOR LEADS	DIFF. RELAY PROTECTION ON MAIN GENERATORS	NEUT. GROUND THROUGH 8 OHM RESISTOR	OISC	MAIN POWER	25,000	Δ-Y	13.5/46 KV.
SAGINAW RIVER 1928 EXTENSION		50 KV. OUTDOOR FRAME MOUNTED SOLENOID OPERATED	VERTICAL DUPLICATE BUS	22 KV	NONE	DIFF. RELAYS ON GEN. + TRANSF. OVERLOAD RELAYS FOR SYNCHRONIZING	NEUT. OF GEN. + AUTO-TRANSF. CONNECTED TOGETHER AND GROUNDED	OIWC	GENERATOR TRANSFORMER	37,500	Y-Y	2+/12 KV.
STATION C P.G. & E. CO. 1928 EXTENSION		1-0-22 SOLENOID OPERATED AND 2-M-206	USUAL DOUBLE BUS HORIZONTAL	12 KV.	NONE	DIFF. RELAYS ON MAIN GENERATORS	GROUNDED SOLID	2-7500 KV.A 3 PHASE 4-150 SINGLE 2-200 PHASE	AUX. POWER AUX. POWER		Y-Δ Δ-Δ Y-Δ	12/2.3 2.3/0.23 +1/0.23 KV
HORSESHOE LAKE STATION 1928 EXTENSION		73 KV. OUTDOOR SOLENOID OPERATED	OUTDOOR SUSPENSION TYPE INSULATORS ON STL. FRAME	63 KV	NONE	DIFFERENTIAL RELAYS ON GENERATOR + TRANSF. BANK.	GENERATOR AND TRANSF. BANK SOLIDLY GROUNDED	OISC	MAIN POWER	3-SINGLE PHASE 12,500 KV.A.	Δ-Y	13.2/36+/63 KV.
365 LB. EDGAR 1928 EXT. 1215 LB.		14 KV. SPRING AND MOTOR OPERATED	VERT. ISOLATED PHASE	14 KV.	4% IN 75,000 KV.A. GEN. LEADS	DIFF. RELAYS TRIPPING FIELDS, MAIN, NEUTRAL + AUX. GEN. O.C.B'S. CO_2 FIRE GAS TO COOLING CHAMBER.	NEUT. GROUNDED VIA O.C.B. AND 40 OHM RESISTOR	OISC OISC OISC	STA. POWER TRANSMISSION "	4000 KV.A. 12,000 - 25,000 -	Δ-Y Δ-Y Δ-Y	14/23 14/25 14/110 KV.
		14 KV. SPRING + MOTOR OPERATED 14 KV. INDOOR TRUCK SOLENOID OPERATED	VERT. ISOLATED PHASE	14 KV.	NONE	DIFFERENTIAL RELAYS TRIPPING FIELDS. MAIN O.C.B	NONE					
HUDSON AV. 1928 EXTENSION		27 KV. SPECIAL UNITS FOR VERTICAL PHASE ISOLATION	VERT. ISOLATED PHASE	27.6 KV.	10% AT 137,500 KV.A. 27,600 V. 2880A	DIFF. RELAY PROTECTION ON MAIN GENERATORS AND AUTO TRANSFORMERS	SOLID NEUTRAL GROUND	3-OISC SINGLE PHASE	MAIN POWER WITH TERTIARY AUX. POWER WINDING	45,833 KV.A. SINGLE PHASE	AUTO. 3 ARE Y CONNECTED WITH SOLID GROUNDS	13.8/27.6 KV.
GOULD ST.		15,000 V. INDOOR INDIVIDUAL TANK TYPE	VERT. ISOLATED PHASE	13.2 KV.	ON FEEDERS ONLY 3/4 OHM IMPEDANCE	DIFFERENTIAL PROTECTION ON MAIN GENERATORS. CURRENT BALANCE AND OVERLOAD ON FEEDERS	NEUT. OF MAIN GENERATOR SOLIDLY GROUNDED	3-OISC 1Φ 6-OISC 1Φ	STA. SERVICE STA. LIGHTING	1000 KV.A. AT 40 DEG	Δ-Δ	13.2/0.46 0.46/115 KV.
TORONTO 1928 EXT.		11 KV. INDOOR CELL MOUNTED MOTOR OPERATED	STD. CELL	11,500	NONE	DIFF. PROT. ON MAIN GEN	GEN. NEUTRAL SOLID TO GROUND	OIWC	MAIN POWER	3-12500 KV.A/UNIT	Δ-Y	11/132 KV.
TRINIDAD		70+132 KV. OUTDOOR MOTOR OPERATED	OUTDOOR HORIZ	60+ 132	NONE	DIFF. PROT ON MAIN GEN.	NEUT. GROUNDED THROUGH SOLID CONDUCTOR	OIWC	MAIN POWER	6-8333 SINGLE Φ	ΔYY	12.5/60/132 KV.
UNIT NO. 5 CRAWFORD 1928 EXT.		15,000 V	VERT. ISO. PHASE	12,400	5250 AMP. 3% 1 PHASE	BALANCE DIFF. PROTECTION ON GENERATORS + ALTERNATOR FAULT BUS IN SW. HOUSE OVERLOAD FOR SECTION ALIENS 5%	NEUT. MAY BE GROUNDED THROUGH 30 OHM RESIS.	A-B-C OIWC	TRANSMISSION	20,000 EACH Φ	Δ-Y	12/66 KV
UNIT NO. 6	DITTO	15,000 V.	DITTO	12,400	6000 AMP. 3% 1 PHASE	DITTO	DITTO	— COMMON FOR ALL 6 UNITS —				
LAKE PAULINE		15,000 V. OUTDOOR	OUTDOOR HORIZONTAL SPACING	13,800	NONE	DIFFERENTIAL PROT ON MAIN GEN	NEUTRAL SOLID	OUTDOOR OISC	MAIN POWER	3-1Φ 666 EACH	Δ-Y	13.2/66 KV.
U.S. RUBBER CO		7500 V. SOLENOID OPERATED	VERT. ISOLATED PHASE	2300	NONE	DIFFERENTIAL ON GENERATORS & FEEDERS	NEUTRAL GROUND THROUGH 30 OHM RESISTOR	OC OUTDOOR	POWER.	1-1000 2-2500 3-700 4-750 3-500 3-400 3-333	Δ " " " " " "	2.3/0.44 2.3/1.1 0.44/0.125 KV.
ACHESON HARDEN		AIR C.B. 1200 AMP. 600 V	HOR GROUPED	230	NONE	NONE	LAMP DETECTOR 115 V. 0.11 AMP.					
PISTON RING CO.		HAND O-C BREAKER	VERT. GROUP	480				OISC	LIGHTING	225 KW	Δ	0.48/0.12
ANGLO-CANADIAN			— NO DATA SUBMITTED —									
SORG PAPER CO.		6,600 V. INDOOR SOLENOID OPERATED	GROUPED PHASE IN CLOSED COMPARTMT.	6,600	NONE	DIFFERENTIAL RELAY PROTECTION ON MAIN GENERATORS	NOT GROUNDED	OISC	HOUSE AUX	600	ΔΔ	6.6/0.48
STANOLIND		IRON CLAD SOLENOID OPERATED	IRONCLAD	2300	6% 6000 KV.A. IN REFINERY FEEDERS 4% 2500 KV.A. IN STR. FEEDERS	DIFF. RELAY PROT. ON MAIN GEN	NONE	OISC	REFINERY DISTRIBUTION	VARIOUS CAPACITIES	Δ Δ	2.3/0.46 KV.

Differential and split conductor relays are practically the only types of relay protection provided on modern generators. It is not considered advisable to provide overcurrent relay protection because, in most cases, it is essential to keep the generator on the line under all conditions except that of internal failure. Since the bus and feeder breakers are usually provided with overload protection, short circuits or grounds on parts of the system beyond the generator are usually removed before damaging the generator.

Grounding Practice

Nearly all the stations listed show that some method of grounding the generator neutral is used. In some cases, a solid ground connection is used while in others a low resistance is placed in series with the ground connection. The great advantage of grounding is that it enables a fault on one phase of a cable to be isolated before it develops into a short circuit between phases. Furthermore, with the neutral grounded the maximum voltage of any conductor above ground is only 58 per cent of the voltage between phases.



SECTION THROUGH HOLLOW SQUARE BUS AT CHIPPEWA FALLS

In many instances, it has become practice to connect all the neutral points of the different generators to a common ground bus, which, if the system be a high voltage one, is grounded through a resistance. Under certain conditions, however, it is found that triple frequency currents tend to circulate between the generators via the neutral bus which prevents this method from being used. Where this condition exists, it is the practice to ground only one generator at a time. This method, it will be noted, is employed at Cahokia Station.

While, in most stations, the use of one resistor between the ground bus and the ground is satisfactory, there are times when it is more desirable to use a separate resistor in the lead from each generator to the ground bus. With this arrangement, a fault to ground does not cause a potential rise on the ground bus and there is no danger of heavy currents circulating between machines.

Values of resistances used in the ground connection it will be noted, vary widely and seem to follow no general rule. Some years ago, the subcommittee on grounding of the A. I. E. E. reported, after an investigation, that the average value was about 1500 v. per ohm. This rule, however, does not seem to have been followed in determining the ground resistance of the stations here considered.

In the matter of bus construction, attention is called to a method recently developed in which the bus is first covered with an insulation which may be wrapped on in the field or factory, using a special machine designed for this purpose, or may consist of molded compound assembled on the bus in the field. This insulation is run through the clamp of the insulator and the assembly is then mounted on the standard insulator.

In place of concrete inner walls forming the breaker cells, the use of steel cubicles has been proposed. In large substations, such steel cubicles have actually been used in isolated phase designs. This type of construction provides a complete metal inclosing structure for all elements of the circuit.

An interesting development in bus construction, which, although not new this year, has had several additional applications is the square type of construction. It has been found in tests at high current densities that the temperature distribution in the ordinary parallel bar type of bus is not uniform, because of the shielding effect of the outer bars. To overcome this, in the new arrangement, the bars constituting the bus instead of being placed side by side, are placed so as to form the sides of a square. An interesting installation of this kind was made recently at the Chippewa Falls plant of the Northern States Power Co., a section of which is shown in the illustration. The bus is tapered by merely removing one of the sides when a point is reached where the load decreases. The entire bus is enclosed in a sheet iron enclosure, with openings arranged as shown.

Transformers and Transmission Equipment

Transformer practice in generating stations has shown no radical changes. The oil insulated self-cooled type of transformer is used in most of the stations listed although, in several instances, the water-cooled type is installed. The delta star connection seems to be most popular as may be noted from the table.

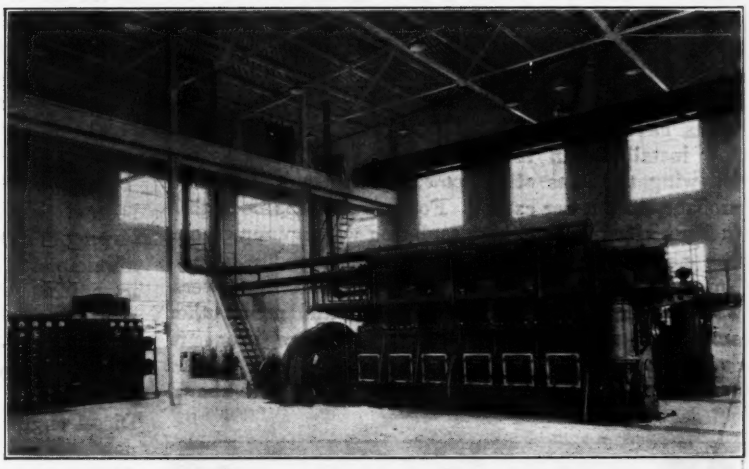
An extremely interesting development this year in transmission practice was the first installation of series capacitors at Ballston, N. Y., on the lines of the New York Power and Light Corporation. These capacitors effect the compensation of the transmission line reactance. The use of the series capacitor to compensate for transmission line reactance is a new advance in electrical engineering, for the practical application of such a capacitor has presented problems heretofore unsolved.

The theory involved is quite simple. A capacitance placed in series with a reactance can be made to compensate for the reactance if $\frac{1}{2\pi f C}$ is made equal to $2\pi f L$. For such a circuit, the potential drop across the capacitor for all values of current is equal and opposite in phase to the potential drop across the reactance. If the circuit is a transmission line, only the drop due to the ohmic resistance of the line affects the regulation of the circuit. With a compensated circuit of this kind, the characteristics of direct-current transmission are approximately obtained, yet with the simplicity and advantages of alternating-current transmission.

At the Ballston installation, three 415-kv.a. capacitors are installed on a 33,000-v., three-phase circuit running from Ballston to Amsterdam, N. Y. The immediate effect of the cutting in of these units was an increase of the load current in the circuit from 33 to 67 amp., and an appreciable increase in the voltage on the distribution buses at Ballston.

Representative Trends in Diesel Power Practice

INCREASE IN SIZE AND SPEED DECREASE IN UNIT WEIGHT, SIMPLIFICATION OF DESIGN AND OF CONTROL OF OPERATION AND INCREASE AND REFINEMENT OF AUXILIARY EQUIPMENT ARE CONTEMPORARY DIESEL TRENDS. RECORD KEEPING THROUGH USE OF BETTER INSTRUMENTS LEADS TO MORE EFFICIENT OPERATION. BY R. C. PAUL*



ONE OF THE MAJOR trends in Diesel engine design has been to larger sizes. The first engines built in the nineties were of 100 to 200 hp. This, of course, limited the field of usefulness of this type of prime mover. They were used then principally in small generating stations and industrial plants. By 1910 to 1915, the size limit had extended to approximately 500 hp. This, of course, increased the field for their use and Diesel engines were then considered in the selection of units for much larger power stations and with multiple unit installations quite a reasonable sized Diesel power plant was possible.

INCREASE IN UNIT SIZE IS PROMINENT TREND

Gradually, larger sizes have been possible until several different engine manufacturers in America are now in a position to build units up to 10,000 hp. Engines of this size in multiple unit stations make possible a good sized Diesel station without the necessity of installing an unreasonable number of units. A number of 4000 and 5000-hp. units have actually been installed in the United States. In Europe even larger units have been built and are now in successful operation. In Germany a 15,000-hp. Diesel engine has been in operation for some time and we understand that even larger units are being built. The 15,000-hp. unit referred to is directly connected to a generator in a central station and is supplying a town with electricity.

Much of the development of the Diesel engine in large sizes has been in the marine field. The United States Shipping Board, through its conversion program, has fostered this development here in America. A number of 5000-hp. Diesel engines have replaced uneconomical steam engines in vessels which were built for the government during the war. It is hoped by naval men that this development may save our merchant marine. In Europe, even larger motorships have been equipped with Diesel engines. Such ships as the Swedish Motorship "Gripsholm," the British "Asturias" and the Italian Motorship "Augustas" are powered with approximately 7500-hp. units.

Design of Diesel engines has tended toward lighter weight. While this is not as important in the stationary field as it is in the marine field, it does tend to lessen the investment for a given installation, both in cost of equipment and in cost of power house. This reduction in weight per horsepower output is only a natural development. When the Diesel engine was young, engineers knew they were dealing with forces of a magnitude that they had never coped with before and the tendency was to be cautious. Stresses and forces are better understood by the designing engineer now and the material is distributed to better advantage. Sections are made thinner in the modern engine, yet, because the problems are better understood, nothing is sacrificed in strength or stiffness. Higher speed, too, has been the trend in the design of Diesel engines. Higher speed must be divided into two distinct developments, first, higher rotative speeds and, what is probably more important, higher piston speeds.

ROTATIVE AND PISTON SPEEDS INCREASING

Increasing the rotative speed of a given engine increases its power but several factors enter in. The inertia forces increase very fast, placing added strain on the reciprocating parts and bearings. Design of these parts must be carefully considered; all unnecessary weight in the reciprocating parts must be omitted and bearings designed with maximum surface. Modern alloy steels and heat treatment have helped greatly in the reduction of weights of reciprocating parts. The important feature in the piston speed is the rubbing speed. Today piston speeds are used which were at one time thought impractical. Again this is due to a better understanding of the problem. At one time, 800 to 900 f.p.m. was thought to be the limit; today this has been increased from 40 to 50 per cent in commercial heavy-duty engines and even more in special engines.

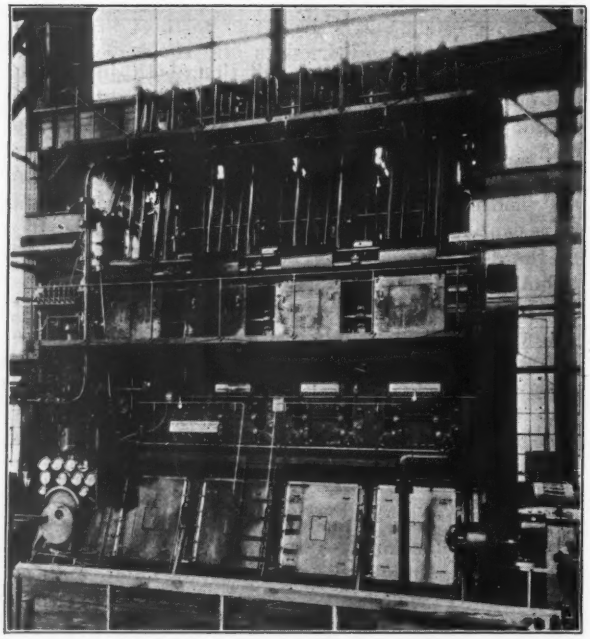
SIMPLIFICATION AND EASE OF CONTROL

That trend in the design of the Diesel engine which is the most apparent to the eye is simplification. Much more attention is now paid to symmetry, straight lines and pleasing appearance. Closer attention to piping has aided. The remark has been made that Diesel engines built a few years ago looked like a pipe shop. Often the piping was hardly considered until the engine design was completed, which resulted in a maze of piping running in all directions. Today, the piping on

*Engineer, McIntosh & Seymour Corp., Auburn, N. Y.

a Diesel engine is so placed as to be inconspicuous. This feature has a concrete value in that less pipe is used, making a cheaper, better construction and one that is more easily attended.

In the application of Diesel engines, marked developments have been made. More auxiliary equipment is now installed. In this particular, Diesel engines are following the lines of all power plant work, although probably to a lesser extent. Formerly an engine with a fuel transfer pump and a circulating water pump, if one was necessary, had all that was considered essential. Now heat exchangers, waste-heat boilers, cooling towers, water softeners, air filters, centrifuges and many other auxiliaries are used. Often engineers are prone to overemphasize the auxiliary equipment. The Diesel engine, in itself, is the most efficient prime mover known



REVERSIBLE DOUBLE-ACTING McINTOSH & SEYMOUR MARINE DIESEL ENGINE OF LARGE SIZE

today, which alone makes it possible to compete with other types of prime movers, but when, in an endeavor to make the installation more economical, the engineer installs so much auxiliary equipment as to make it burdensome, the advantage of the additional equipment is lost.

Records and Recording Instruments Play Part

Better records are kept today in most power plants than was formerly the rule. More and better instruments are being installed today, making better records possible. But, as in the case of the auxiliaries, the equipping of a Diesel engine with instruments can be, and sometimes is, overdone. Instruments are valuable only for the records they make possible. If records are not kept, or if the instruments are neglected until they are out of order and no longer give correct records, the value is lost. Often the number of instruments and their character must be determined by the type of attendance the engine will have. Sensitive instruments in the hands of those who do not know how to use them are not worth the investment. Likewise if the records obtained from instruments upset the operator and cause him to be alarmed over inconsequential things, the instruments might better be omitted.

Diesel Application Widening

In the application of Diesel engines, too, there has been a widening field. They are now installed in a large number of central stations, both privately and municipally owned. General reasons for their wider use in this field are two. Men engaged in public utility work are usually conservative, slow to adopt new methods or equipment. This is necessarily so, for unreliability cannot be tolerated. The Diesel engine had to be proven before it was adopted by these men. The Diesel engine has been proven by time and use and is now looked on with much more favor than formerly. Also, larger size units have broadened its field in central station work. In the industrial field, new uses have developed for the Diesel engine. This is due partly to acceptance by users and partly to the development in larger sizes, smaller sizes, lighter weight and higher speed.

In special applications such as dredges, shovels, locomotives and trucks, the Diesel has moved steadily forward. Now it is taking to the air, as a Diesel-engined airplane made its first flight recently.

Fundamentals of Diesel practice have changed little in the past few years. This is true because the economies of this engine are inherent and can be changed only slightly but in the design and application, the Diesel engine like all machinery has moved forward to serve mankind more effectually.

Coal Carbonization at Lukens Steel Co.

Contract has been closed with the Lukens Steel Co., Coatesville, Pa., for building a low-temperature coal carbonization plant, as announced by George E. Learnard, president of the International Combustion Engineering Corp. This will be the first such plant identified with the steel industry and the second installation in the United States, the first being under way near New Brunswick, N. J. The new plant will be owned and operated by the International Coal Carbonization Co., a subsidiary of the International Combustion Engineering Corp., and will produce approximately 1,750,000 cu. ft. of gas daily to be sold to the Lukens Steel Co. for heat treating of steel. Byproducts will be tar, light oils, a high grade motor fuel and domestic fuel which will be sold locally. The initial installation will have six retorts, capable of handling 500 t. of coal a day and yielding 300 t. of the domestic fuel.

Electricity—What It Is and How It Acts

Because of the special nature of this issue of Power Plant Engineering, it has been necessary to omit the regular Electrical Department and also Part XV of the series "Electricity—What It Is and How It Acts." This part will appear in the January 1 issue.

A man who is not able to make a bow to his conscience every morning is not in a healthful condition.

Diesel Power Plant Practice Trends

IMPROVEMENT OF CONTROL METHODS AND MANAGEMENT AND INCREASE IN UNIT POWERS ARE OUTSTANDING FEATURES IN THE DIESEL FIELD

MOST OF THE DIESEL engines now produced in this country are being built under foreign patents, although American ideals of simplicity and accessibility have and are constantly modifying those designs. Occasionally new engines are brought out which, although taking advantage of foreign experience, do not encroach upon claims covered in foreign designs. Over sixty companies located in the United States are now building Diesel engines.

Larger Diesels Are in Sight

Greater use of large size Diesel engines is one of the trends that is noticeable in this field but America, due to the more favorable conditions to use of coal here, lags far behind its European cousins in its adoption of the larger Diesel engine sizes although increase in size of units here will doubtless take place in the near future. At present the larger units are used in marine practice. Limitations of cylinder sizes are gradually being overcome as will be shown later.

Certain dominant characteristics of oil engines manufactured in this country by twenty-seven different manufacturers are listed in the table. It will be noticed that this includes a number of semi-Diesel and a few low compression engines. Of these manufacturers, only two employ double action and these two build large size engines. Larger capacity per unit has been sacrificed by the other builders in favor of the greater simplicity of construction of single-acting internal combustion engines, due to freedom from stuffing boxes and crossheads and to greater simplicity of piston-cooling and of valve-operating mechanism.

Choice between two-stroke-cycle and four-stroke-cycle appears to be quite evenly divided, being in the ratio of 15 to 14. Two of the manufacturers produce both two and four-cycle engines, permitting choice on the part of the customer. The larger table lists 21 engine sets of the two-cycle and 23 of the four-cycle type.

Solid Fuel Injection Favored

According to the table, we find 75 per cent of the manufacturers to favor solid or airless fuel injection. This predominance is due in part to the greater simplicity of this form of fuel injection particularly in the smaller sizes and to the fact that low compression engines appear in the list. In the table on plant characteristics, 28 engine sets are listed as using air injection while 20 use solid fuel injection. It will be observed that 10 engines are two-cycle with solid injection while only five are four-cycle with air injection. Some manufacturers who build engines of both cycles employ the above corresponding fuel injection methods. Eleven of the manufacturers report using the four-cycle solid injection while only four report two-cycle air injection systems. Operators report that an air injection engine will burn a heavier and dirtier oil than one of the solid injection type and will also negotiate overloads better but it labors under the disadvantage of having an additional compressor.

Compression pressures for Diesel engines appear to remain at or near the 500-lb. mark although attempts have been made to reduce this pressure. Grouping fuel injection pressures into four characteristic groups, we find seven use pressures below 800 lb., ten use pressures ranging from 800 to 1200 lb., two use pressures between 1200 and 2000 lb. and seven use pressures between 2500 and 4000 lb. Two employ pressures of 6000 lb. for fuel injection. This tendency toward high fuel pressures is

TABLE I. DOMINANT CHARACTERISTICS OF OIL ENGINES PRODUCED BY 27 DIFFERENT MANUFACTURERS

Mfr.	Hp. Range	Cycle	Type Fuel Inject.	Pressure Lb. Comp-ression	Pressure Lb. Fuel In-ject.	Hp. per Cyl.	Piston Speed Ft. Per Min.	Wt. per Hp. Lb.
1	50-2000	4	solid air	450	900-1100	25-200		
2	70- 700	4	air	475	750- 850	70-115	900	300-500
3	50- 360	2	solid	500	800	50- 60	771	200
4	20- 500	4	"	380	3800	10- 75	650-750	160
5	40-1700	4	"	360	4000	20-170	1140	100-125
6	to 6000	2	air	450-500	900-1200	535-625	850-1060	250-300
7	7- 900	2	solid	120	400	7-100	700-900	75-110
8	65- 400	2 & 4	"	200-400	1500-4000		756-810	250
9	92- 180	4	"	375	3500-5000	23- 30	1032-1458	35
10	165-7000	2 & 4	air	500	800-1000	65-700		50-250
11	6- 200	2	solid	160	600	6- 50		
12	150- 750	4	"	400	6000	50-125	650-900	125-175
13	25- 840	2	"	500	1500	12½-140	730-875	80-350
14	15- 80	2	"	200-225	400-1200			
15	1500-5000	2	air	450-500		500-1000	700-900	150-220
16	80- 180	2	solid	2250	300	10- 45	600-650	133-190
17	100-8000	4	air	500	1000	25-1000		
18	18- 100	2	solid	550	550	7½- 18	658	35-150
19	45- 360	2	"	450	1200	45- 60	771-800	220-300
20	100-1600	4	"	350-450	2000-6000	40-200	875-1000	115-200
21	600-3750	2	air	480	1050	200-670	780-930	167-335
22	50-2000	4	solid	360	2500	25-175	750-1000	
23	3½- 75	2	"	150	500	3½- 15	700	80-125
24	25- 250	2	"	300		25- 40	708-825	160
25	27- 400	4	"	400-440	2000-3500	15- 50	700-900	150-180
26	30- 450	4	"	350		15- 75		95-140
27	44-1800	4	"	360	3800	22 up	up to 800	109-250

a result of a desire to perfect combustible mixture in the combustion space by means of turbulence. It also effects cleaner spray nozzle action and reduces nozzle troubles.

Sizes of cylinders are increasing. Grouping the horsepowers per cylinder reported, we find 30 makes of engines having less than 25 hp. per cylinder, 19 makes having from 25 to 75 hp. per cylinder, 10 makes with from 100 to 200 hp. per cylinder, 5 makes from 500 to 700 hp. and 2 makes with as much as 1000 hp. per cylinder. Piston speeds as well as rotative speeds are increasing. The range given in the table is from 600 to 1458 with an average of 874 ft. per min. Piston speeds of 1000 ft. per min. are now attained in a number of large size Diesels.

Lighter Weights per Horsepower

Reduction in weight is now sought by a number of builders and the trend toward lighter weights is evident. Higher piston speeds obviously influence reduction in weight. Weights per horsepower reported range from 35 to 500 lb. with an average of 177 lb.

Due to the short time for admission of charge, which is inherent in two-cycle engines, low pressure precompression of the air charge, in order to increase its velocity of admission into the engine cylinder, is required. In a number of the engine sets listed, this

precompression is accomplished in the crankcase of the engine, which is the simplest method. Other manufacturers, desiring a more complete scavenging of charge, employ air compressors attached to or integral with the engine.

Supercharging was employed in the Odessa plant in order to compensate for the loss of engine capacity due to the high elevation at which the plant is operated. The grade of fuel used in the plants under discussion ranges from heavy crude oils to light gas-oil having gravities ranging from 12 to 36 Baumé.

Low machine factor is due, in some cases, to the necessity for using large size engines for light loads, owing to installation of only large size units. Some

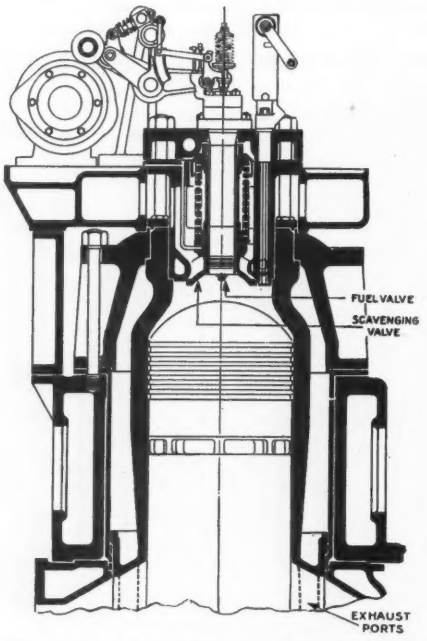


FIG. 1. INLET VALVE SURROUNDS FUEL VALVE WHICH IS CENTRALLY LOCATED IN THE AXIS OF THE CYLINDER. ABSENCE OF JOINT AT CYLINDER HEAD INCREASES EFFICIENCY OF COOLING

plant operators, recognizing the fact that all Diesel engines of a given type, whatever their size, have practically the same economy, have installed engines of graded sizes in order to provide small engines for use under the daily light load periods.

Comparison Should Be by Net Output

In comparing various Diesel plants with each other or in comparing them with plants of other types, account should be taken of the power required for station work and only the net output used for the comparison. The amount of power required for circulating cooling water, for pumping fuel oil into main tanks and from storage tanks into day tanks, for operating repair machinery and for station lighting, all should be deducted from the gross power generated. In some cases from 5 to 7 per cent of the gross power is used for such station purposes.

In fuel oil storage, examination of the table discloses preference for steel tanks placed above ground. Oil storage at the Madison, S. D. plant is unique, in that it is located under the cooling tower basin, thus not only providing an inexpensive means of storing the fuel but avoiding heating it for transference. Flooded lubrication of running parts and lubricating oil purification is carried on in practically all modern large size Diesel stations, preference being given to centrifugal purification, although some operators are realizing the advantages to be gained by adding settling tanks to their purifying apparatus.

Most of the plants under investigation employ the closed system of cooling water and cooling towers but a number of plants, located where the available water is exceptionally soft, use the open system. Modern trend in Diesel stations points emphatically toward use of water treatment. Inspection of a large number of plants has shown that, in almost every case of cylinder head or jacket breakage, although this was only one of several possible contributary causes, the final trouble lay with the untreated cooling water.

Concentrate Should Be Filtered Out

Many base exchange softeners have been successfully used in Diesel plants but recent developments have indicated that, in connection with these as well as with other softeners which do not remove concentrate, such removal is advisable, hence filters of some kind have supplemented Zeolite softener installations. Where an ample supply of poor water is available, it is used at times in a closed system for cooling treated water.

Awakening of interest in clean air for combustion purposes is demonstrated by the common use now made of some kind of filter. Mere screening of incoming air is no longer considered adequate, in most situations. Trapping of dust particles by means of multicellular filters appears to be the most popular method used; a few use water spray washers. With the use of air filters, the location of the air intake is of less importance than formerly but intakes placed in locations where air contamination is least reduce the work required of the filter and lengthen the period between cleaning of filters that are not of the self cleaning type.

Exhaust gas temperatures are held, for the most part, at about 600 deg. F. Modern plants are now being equipped with handy temperature measuring instruments for indicating the temperature not only of exhaust gases but also of cooling water. It is recognized that these temperatures indicate the condition of operation and that abnormal temperatures indicate need for immediate investigation and correction of some maladjustment. Increasing use of adequate records in Diesel plants aids much in providing means not only for better control but also for studying operation methods and getting better efficiency.

Exhaust gases are no longer cooled by spraying water in the exhaust passages, a practice which leads to rapid corrosion. Cooling of such gases by other means is, however, almost universal in modern Diesel plants. Cooling of the manifold by means of a water jacket seems to be the most popular method. Only three cases of exhaust pipe cooling are noted in the table.

Exhaust mufflers, when of tank form, are now usually cylindrical instead of pot shape as formerly and are made of cast iron. A few plant operators use concrete pits for muffling the sound of exhaust, sometimes in conjunction with tank mufflers. Where exhaust sounds

DIESEL PLANT DATA

PLANT	LOCATION	KIND OF SERVICE	H.P. OF UNITS	NO. CYL.	CYCLE	FUEL INJECT.	COMBUSTION AIR COMPRESSION	BAUME° GRAVITY + FUEL	LOAD FACTOR PLANT	LOAD FACTOR MACH.	OIL CONSUMPT. FUEL-*/BR.HP-HR.	OIL CONSUMPT. LUB-HP-HR/GAL.	FUEL OIL STORAGE TYPE	FUEL OIL STORAGE CAP. GAL.	TYPE LUB. OIL PURIFICAT'N	COOLING WATER METHOD	COOLING WATER TYPE SYSTEM	COOLING WATER TEMP°F IN	COOLING WATER TEMP°F OUT	CAP. GAL. C. TOWER BASIN	WATER TREATME'T TYPE	WATER TREATME'T CAP. G/DA.	LOCAT'N OF AIR INTAKE	AIR FILTER TYPE	AIR FILTER CAP. C.F.M.	EXHAUST TEMP. DEG.F.	EXHAUST COOLING	EXHAUST MUFFLER
ARIZONA EDISON CO.	GLOBE, ARIZONA	LIGHT + POWER	2-300	8	4	AIR	INTEGRAL WITH ENGINE	24	35	56	.0.51	2,100	2 STEEL TANKS ABOVE GROUND	1-27,000 1-17,000	CENTRIF-UGAL	TOWER		74	115	18,000	ZEOLITE	5000	ROOM			660 MAX.	MANIFOLD	TANK
CENTRAL STATES ELECTRIC CO.	ARMSTRONG IOWA	"	1-360 3-600	6 6	2 4	SOLID AIR	CRANKCASE INTEGRAL COMPRESSOR	30-32 26-28	†† 1,401,578	† 800	0.62	1,118	4 TANKS ABOVE GROUND	19,200	"	"	CLOSED	65	120	34,400	PERMUTIT	14,000	ROOF	MULTI-CELL	3,500 7,000	525 780	"	SOUND WAVE FILTER
"	WALTHILL NEB.	"	1-100 1-240 1-360	2 4 6	2 2 2	SOLID " "	CRANKCASE PISTON "	32-36 26-28 26-28	†† 233,020	† 160	0.965	692	2 TANKS ABOVE GROUND	1-192,000 1-12,100	"	"	"	65	120	34,400	"	26,000	AT ENG. "	—— ——	—— ——	525 600 600	"	SOUND WAVE FILTER
GENERAL WATER WORKS & ELECTRIC CORP	BLOSSOM TEXAS	"	2-240	4	2	AIR-LESS		28 FUEL OIL	36		0.46	2500	2 STL. TANKS & PIT	10,000 EACH	"	"	"	85	110	16,000	NONE USE RAIN WATER		OUTSIDE GROUND LEVEL	MULTI-CELL	2400	490	——	CONCRETE PIT
"	CLIFTON TEXAS	"	1-400 1-200	4 4	4 2	AIR-LESS	INTEGRAL COMP.	24 FUEL OIL	48		0.42	6,000	2 STL. TKS. UNDER-GROUND	10,000 EACH	"	"	OPEN	80	110	10,000	"		"	"	1600	120	MANIFOLD	CONC. PIT SOUND FILTER
"	HICO TEXAS	"	2-600	6	4	AIR	"	"	55		0.42	6,000	2-STL. TK. ABOVE GND.	10,000 EA.	"	"	CLOSED	85	105	16,000	"		INSIDE MEZZ. FLOOR	"	3600	120	"	C.I. SOUND WAVE FILTER
"	PECOS TEXAS	"	2-1250	5	2	AIR	"	"	46		0.45	12,000	2 STL. TK. IN PIT	18,000 12,000	"	"	"	93	128	15,000	LIME	13,200	OUTSIDE GROUND LEVEL	"	19,400	600	——	C. I. TANK
"	SILVER CITY NEW MEX.	"	2-600 2-1125	6 6	4 4	AIR-LESS		"	55		0.45	6000	3 STL. TK. ABOVE GND.	10,000 EA.	"	"	"	100	145	16,000	LIME-SODA	13,200	"	"	9,600	600	MANIFOLD	WELDED STL. TANK
"	TEXAS CITY TEXAS	"	2-700 1-560	5 4	2 2	AIR-LESS		28 F. OIL	38		0.46	3000	3 STL. TK. ABOVE GND.	"	"	"	"	85	105	15,000	NONE - USE RAIN WATER		"	"	19,400 9,600	520	"	CONC. PIT
IOWA UTILITIES CO.	LINEVILLE IOWA	"	1-75 1-240	2 4	2 2	SOLID "	CRANKCASE PISTON	32-36 26-28	†† 160,617	† 110	1.35	465	2 TK. ABOVE GND.	12,100 19,200	NONE	"	"	80	125	17,000	—— ——	—— ——	—— ——	—— ——	—— ——	—— ——	"	SOUND WAVE FILTER
NORTHWESTERN POWER & LIGHT CO.	CORRECTION-VILLE IA.	"	1-240 1-360 1-600	4 6 6	2 2 4	SOLID " AIR	CRANKCASE " COMPRESSOR	28-32 28-32 26-28	†† 8,029,359	† 320	0.708	482	3 TANKS ABOVE GND.	19,200 EACH	CENTRIF.	"	"	65	120	34,400	PERMUTIT	14,000	ROOF	MULTI-CELL	3,500 5,000 7,000	525 525 780	"	"
"	PETERSON IOWA	"	1-360 2-600	6 6	2 4	SOLID AIR	PISTON	26-28	†† 1,545,783	† 525	0.68	830	2 TANKS ABOVE GND.	24,000 11,600	"	"	"	65	125	34,400	"	15,000	SIDE WALL	"	5000 7,700	550 780	"	"
"	SIBLEY IOWA	"	2-600	6	4	AIR	COMP.	26-28	†† 829,600	† 310	0.675	1280	3 TANKS ABOVE GND.	19,800	"	"	"	65	120	34,400	"	14,000	ROOF	"	7000	600	"	"
TEXAS ELECTRIC SERVICE CO.	ODESSA TEXAS	"	3-500 2-1250	4 5	4 2	AIR "	CENTRIF. SUPERCHR " " + RECIP. BLOWER INTEGRAL WITH ENG.	20-24 FUEL OIL	85	78	0.56	1130	2 STL. TK. UNDER GND. 1 STL. TK. ABOVE GND.	20,000 840,000	CENTRIF. & FILTER	"	"	80	120 130	12,000 OVERHEAD 80,000 SURF.	ZEOLITE	108,000	BASEMENT	WATER SPRAY WASHER		——	MANIFOLD & EXH. PIPIE	TANK
TUCSON GAS, ELECTRIC LIGHT & POWER CO.	TUCSON ARIZONA	"	2-500 2-550 2-950 1-3750	3 4 6 6	4 4 4 2	AIR " " "	COMP. " " "	24 24 24 19	* 38.5	* ‡ 365 68.3	0.604	‡ 600 1435 ††	2 STL TK ABOVE GND.	230,000 100,000	CENTRIFUGAL	SPRAY	* OPEN	90	130	30,000	PERMUTIT	40,000	90' STACK	AIR WASHER	20,000	550	MANIFOLD	△
MUNICIPAL POWER & LIGHT PLANT	FREDONIA KANSAS	" PUMPING	2-300 1-600	3 6	4 4	AIR "		28 FUEL & CRUDE OIL					1-CONC. TK. OUTSIDE	46,200	2 FILTERS + SETTLING	——	"	0-90	100				AT MANIFOLD	STRAINER	——	660	EXH. PIPE MANIFOLD	TANK
"	KEARNEY NEB.	L. + P. PUMPING	2-300	3	4	SOLID	PISTON	32-34 FUEL OIL		80	0.421	3000	STEEL TANK UNDER GND.	12,000	RECLAIMER	——	"	60	95				OUTSIDE ABOVE ROOF	SCREEN	——		EXH. PIPE	TANK
"	LAKE WORTH FLORIDA	LIGHT & POWER	1-400 1-800 1-800 1-1125	4 4 4 4	4 4 4 4	SOLID AIR " SOLID	COMP. " "	28	40	18 30 29 28	0.44 0.49 0.50 0.39	2,400 2,000 2,000 2,500	STL. TANKS PARTLY UNDERGND.	2-10,000 3-8,000	"	TOWER	CLOSED	65	110				SIDE BLDG.	MULTI-CELL	19,000	650	MANIFOLD	SOUND WAVE FILTER
"	LOGAN UTAH	STANDBY	1-675	4	2	AIR	CRANKCASE	27 GAS OIL	23		0.45	3,600	2 STL. TK. ABOVE GND.	15,275	CENTRIF.	FROM CITY MAINS	OPEN	36	100	CITY MAINS	—— ——	—— ——	NEAR GROUND LEVEL	"	—— ——	615	"	CONCRETE PIT WITH 4 BAFFLE CHAMBERS
"	MADISON S.D.	L.P.	2-250 1-365 1-600	4 4 6	4 4 4	AIR " "	COMP. " "	26-28	22.64	10.21	0.505	1100	REINFORCED CONC. TANK BELOW GND.	80,000	"	TOWER	"	65	110	36,000	—— ——	—— ——	INSIDE ENG. ROOM	"	—— ——	700	"	C.I. TANK
"	MARSHALL MICHIGAN	"	2-550	5	2	"	"	24-26					2 CONCRETE TANKS	25,000 EA.	FILTER	USE RIVER WATER	"						IN BLDG.	—— ——	—— ——		"	TANK
"	PONCA CITY OKLA.	"	4-1250	5	2	"	"						CONC. TANK BELOW GND.	200,000	CENTRIF.	TOWER	"	90	140	52,000	ZEOLITE		ON GROUND OUTSIDE	UNIT CELL	51,200			C. I. TANK
"	ROCHELLE ILL.	"	1-365 1-550	4 5	4 2	"	COMPRESSOR	32-36 26-30	31	50	0.46	2,300	3 STL. TK. ABOVE GND.	11,500 EACH	GRAVITY FILTER	"	"	85	130	1,600	CHEMICAL	——	ROOF	MULTI-CELL	—— ——	—— ——	EXH. PIPE MANIFOLD	TANK
COMMERCIAL MINING AND ROYALTY CO.	MIAMI OKLA.	INDUST. POWER	3-2250	4	2	"	"	12-14	30		0.505	5,130	2 STL. TK. ABOVE GND.	420,000 EACH	FILTER & CENTRIF.	SPRAY	"	80	120	1,000,000			OUTSIDE	"		600		CONCRETE TANK
SAN ANTONIO PORTLAND CEMENT CO.	SAN ANTONIA TEXAS	INDUST. POWER	2-500 3-1000 1-1500	4 8 12	4 4 4	SOLID		24-26	60		0.38	4000	CONCRETE TANK	168,000	CENTRIF.	TOWER		80	140				ENGINE ROOM	—— ——	—— ——			

*-FOR ALL EQUIPMENT COMBINED FOR YEAR 1927 NOT AVAILABLE FOR OIL ENGINES ALONE
**-FOR 6 ENGINES FOR YEAR 1927
*-FOR THIS ENGINE FROM JUNE TO SEPT. 1928

△-PISTON COOLING WATER FOR CLOSED FRAME. ENGINES TREATED WITH ALUM AND FILTERED
*-CLOSED SYSTEM USING TUBULAR HEAT EXCHANGERS SELDOM USED.
††-600 FOR 5 ENGINES 1420 AND 1435 FOR ALL, 8 MONTHS IN 1928

△-ALL EXHAUST GOES INTO MANIFOLD IN CONNECTION WITH WASTE HEAT BOILER. MUFFLER OF STANDARD DESIGN ABOUT TO BE REPLACED BY ONE OF SOUND WAVE FILTER TYPE
††-NET KW-HR. GENERATED DURING YEAR 1927 †-PEAK LOADS DURING YEAR 1927

are not permissible, as in residence districts, sound wave filter silencers are used with success.

More Attention Given Waste Heat Utilization

Waste heat utilization is now occupying the attention of Diesel power users. Such utilization has the advantage not only of gaining heat that would otherwise be wasted but also of getting rid of this heat which, without such utilization, would require larger provision for its removal. Heat from cooling water and exhaust gases may now be employed for operating auxiliaries. Some operators use this heat for warming fuel oil in tanks or, by circulation, use it for plant warming purposes.

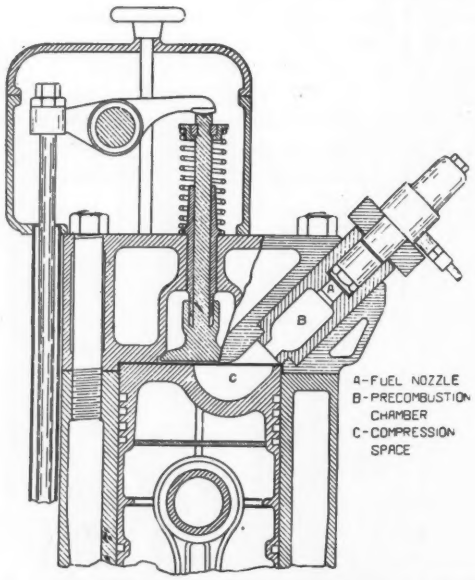


FIG. 2. PRECOMBUSTION CHAMBER CAUSES BURNING FUEL TO BE PROJECTED INTO COMBUSTION CHAMBER, PRODUCING GOOD MIXTURE DUE TO TURBULENCE

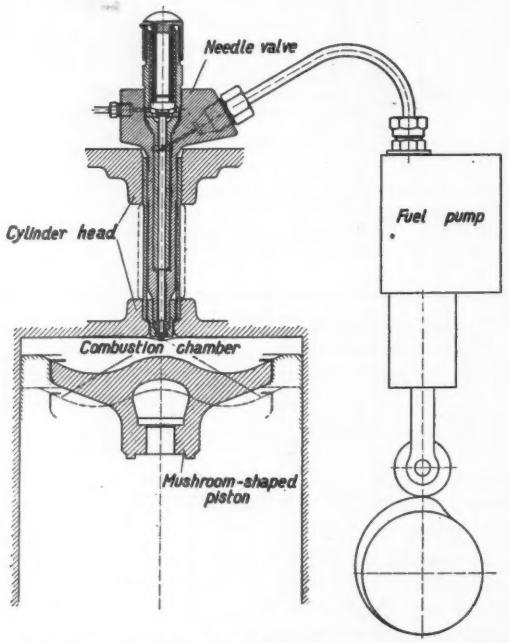


FIG. 3. MUSHROOM SHAPED PISTON HEAD FACILITATES INITIAL IGNITION AND INLET VALVE CREATES TURBULENCE OF CHARGE

Constructional developments are continually being made with a view to improving the combustible mixture and of increasing the flame propagation. Such developments lie principally along three avenues of attack: improvement of spray nozzle action, better scavenging of spent charge and design of combustion chamber. A recent effort toward better scavenging is illustrated in Fig. 1. Here the fuel valve is axially located in the cylinder head and surrounded by the inlet valve through which the scavenging air is passed. Smooth, symmetrical design of combustion chamber and the manner of admission assure good scavenging by the use of a comparatively small amount of air.

Universal effort seems to be made to obtain turbulence of charge. Three different methods of attaining this end may be enumerated as use of opposing fuel nozzles; use of precombustion chambers as shown in Fig. 2; and peculiar design of the combustion space including cylinder head and piston head, illustrated in Fig. 3. In the last case, the hot mushroom construction facilitates the initial ignition and the combustion of the fuel oil injected into the air charge of the cylinder. Turbulence of the air is created by the inlet valve.

From 25 to 30 per cent of the heat of combustion in an internal combustion engine is carried away in the cooling water, the rest being dissipated in the exhaust gases. At least 80 per cent of the heat passed to the cooling water is transferred through the cylinder and piston heads. The advantage, therefore, of avoiding a heavy flange to join the cylinder head to the cylinder body, will be evident.

Ease of Control and Accessibility

Accessibility is another ideal of American design toward which there is a constant trend. Spray nozzles are now so attached to engines that they may be changed while the engine is running. The engine of one manufacturer is so constructed that the piston may be removed by lowering it, detaching the lower section of the cylinder and opening side plates on the engine frame. In cases in which the cylinder head and body are cast integral, it is necessary to remove the piston through the lower part of the engine but this method of removal has the advantage that none of the valves or valve mechanism is disturbed during such procedure.

Diesel plants are characterized by an increase in auxiliary equipment as indicated in the large table and by refinement of method in the use of such auxiliary equipment. Diesel engine application now reaches all types of power but use as a standby source is the most pronounced application.

In many instances, Diesel engines are not only employed as regular power units by central station power companies, such as those indicated in the large table but are often installed by such station operators for immediate use in cases of emergency because they can be installed more quickly than steam turbines. Likewise, Diesel engines may be more easily transferred from one station to another, a procedure frequently used by central stations after the emergency need has passed.

Faults of ignorance are excusable only where the ignorance itself is so.

Refrigeration Activities Touch Many Fields

INCREASED USE OF HOUSEHOLD REFRIGERATORS HAS NOT RETARDED EXPANSION OF THE LARGE REFRIGERATING PLANT. BY N. H. HILLER, JR.*

IN GENERAL, the refrigerating world has advanced in time with the other industries of this country. There have been a number of changes in the methods of installing equipment; in labor saving devices, such as can baskets, multiple dumps, multiple fillers and other apparatus, and all these new devices have done a great deal to increase the overall efficiency of existing plants. More and more plant owners are realizing that it is not as economical to bring an old plant up to date as it is to rebuild with entirely new apparatus. There have been also a number of changes made in the method of ice making, more perhaps in this line of science than in cold storage and other cooling work. All this will be taken up after the general discussion.

LARGE ICE PLANTS STILL IN VOGUE

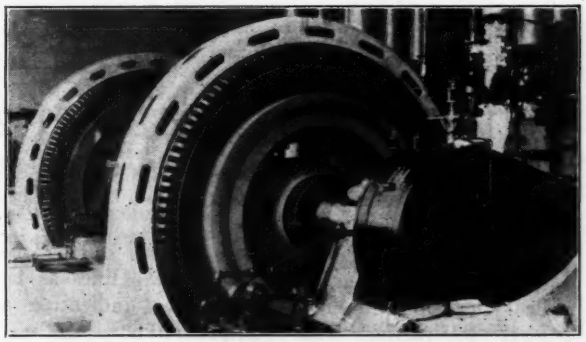
Throughout the North and East, large ice plants are still in vogue. Contrary to the opinion of a great many people, the small household refrigerating machine has not interfered with artificial ice production as much as might be expected. In fact, the very extensive advertising employed by the makers of household machines has really served to boost the sale of ice inasmuch as the advantages of refrigeration have never before been brought to the public with such remarkable advertising.

As a general rule in the North and East, plant owners desire a centralized plant with a large ice storage. The plant is run during the winter months filling the ice storage and during the summer, the plant is run to capacity with the ice storage taking care of the additional sales load. Natural ice is used in the colder portions of the North and East to some extent. It is a recognized fact, however, that natural ice is inferior to artificial ice and as a general rule, the householder prefers the artificial ice cake. The crystal clarity of the modern ice cake as manufactured under the raw water system has done a great deal to reduce the sale of natural ice and the fact that standard artificial ice cakes can be scored in such a manner as to be broken easily into smaller cakes of practically definite weight has done much to win the favor of the user of ice for refrigeration. Because of the low price of electric power, the electrically operated plant has become very popular indeed. There are very few stand-by loads and the overall efficiency of electric plant is far higher than the steam plant, to say nothing of the much lower operating cost and fewer number of employes.

USE OF COLD STORAGE GROWING

In the warehousing field, a number of large cold storage plants have been installed during the year showing the tremendous growth in the use of refrigeration as a preservative. These plants have been installed in a number of our very largest cities, not only in conjunction with railroads but as well with private enterprises. As a general rule, they employ two brine temperatures: the higher one for storage work and the lower one for sharp freezing.

Refrigeration has undergone a great advancement in the ice cream field. In one direction only has it been partially supplanted by a substitute in the shape of carbon dioxide snow or "dry ice." In the shipping of ice cream and ices, dry ice has been remarkably successful. As a freezing and hardening medium, however, refrigeration of the conventional ammonia type has yet to find a peer. Two temperatures are normally used in the usual ice cream factory, one for cooling and freezing and the other for hardening. Throughout the North and East there have been installed several car icing plants and cooling plants. These have been placed in conjunction with various railroads in order to make the matter of car icing far simpler. Refrigeration has found its usual employment through the Northeastern states in the small machine field such as butcher shops, furriers, dairies, etc., and has likewise gained favor in office buildings, apartments and in theater cooling, the latter type of refrigeration generally calling for carbon dioxide.



TWO MOTOR DRIVEN COMPRESSORS IN A SEATTLE ICE CREAM PLANT

JITNEY STATIONS

In the Southern states, certain localities prefer the large centralized ice plant, while there is rapidly gaining favor the small or localized ice plant, sometimes called the "jitney station," for the distribution of ice in a residential district. A number of very attractive plants have been installed by a prominent midwest consulting engineer, such plants being of a type of architecture which harmonizes with surroundings. There is attractive planting around the building and the whole is so made to blend with nearby property that no possible objection can be made. It would seem that in the southern climate where ice is used the year around, such a plant would be successful and thus far this assumption has been found to be correct. Certain sections, such as Florida and South Texas, have installed fruit precooling plants and car icing plants to considerable extent and as the fruit trade becomes greater in

*The Vilter Manufacturing Co., Milwaukee, Wis.

these locations, one may look for further installations.

The West Coast is similar to the Southern Atlantic Coast in the development of refrigeration.

An achievement of importance this year was the development of the Super-Flooded System. In this type of installation for raw water ice making, the boiler type of tank coil has been employed, utilizing a completely flooded system. By such design, it is possible to utilize practically every square inch of coil surface, whereas, in the old type of continuous coil, a great deal of the coil surface was useless. In combination with a suction accumulator of the flooded type, the tank with the boiler type coils has shown temperature difference between brine temperature and ammonia temperature of less than 2 deg. F., a fact which shows efficiency not only in the matter of heat transfer but in the matter of engineering. In the super-flooded system, the ammonia from the liquid receiver is expanded to a pressure corresponding to 33 or 34 deg. F. and atmospheric type of forecooler coils cool the water for the ice cans to less than 35 deg. before piping to the can filler. Not only is the water forecooler so arranged a great adjunct to the system but also it acts as an ammonia forecooler, giving each pound of ammonia circulated in the ice tank coils a greater refrigeration content. A float tank regulator, which is part of this system, maintains the proper level of ammonia in the forecooler and permits a definite quantity of ammonia to be expanded in the ice tank coils. By means of this regulator, the entire system is so balanced that scarcely any attention need be paid to the plant during operation save normal inspections and adjustments.

Both the double suction compressor and the multiple effect compressor have been employed successfully with the super-flooded system. With the latter type of machine, the pressure on the forecooler is balanced automatically according to the load, a point worthy of consideration. Excellent efficiency has been obtained in several installations of this type during the past year and there is no reason why equally good or better results should not be obtained in the future.

Forced Draft Air Cooler

Another piece of equipment which has given good results during the past year is the forced draft air cooler. In this air cooler, there are a number of loop coils of a welded type construction supplied with suction and liquid headers and a regulating device which permits the ammonia to maintain an equal level in all loop coils. Forced draft is supplied by an aeroplane propeller type fan and the blast of air is sufficient to give ample circulation through a large room.

Refinements Characterize Compressed Air Trends

Improvements in Governing Systems, Use of Aftercoolers, Water Traps and Air Filters Are Problems Being Given Greater Consideration. By Frank A. Halleck*

PROGRESS in air compressor practice during the past year has been along conservative lines as no radical developments have taken place, indicating a general satisfaction with equipment now in use. Changes have, however, been made in details of design which will permit the use of compressed air equipment under more exacting engineering and economic conditions.

While speeds will be higher in the future, we have had a breathing spell for the last few years, during which time refinements have been made in governing systems, the use of air cleaners, aftercoolers and water traps. More attention has been paid to better installations, including larger and more direct intake and discharge lines.

Intercooling has been made more efficient by the use of the counter current system; many installations have shown that in the summer time the air going into the high-pressure cylinder is cooler than that taken into the low pressure or intake cylinder. Intercoolers are twice as large as they were a few years ago and are doing better cooling with the same amount of water due to the more efficient baffling of the air and larger cooling surfaces.

Lubrication of the moving parts is continuous and all parts are flooded with oil. Pressure oiling along the lines of modern automobile practice is in the offing and machines with this type of oiling will appear within the coming year.

*Engineering Department, Sullivan Machinery Co., Chicago, Ill.

Compressor Speed

During the past year, the speeds of air compressors have not changed; the big increase in speed came about 10 yr. ago with the adoption of light plate valves; since then the increase in speed has been slow and has remained as shown in the following tabulation, (which is recommended as the maximum by the Compressed Air Society), for the past 3 yr.

For present designs of straight line machines:

6-in. stroke	350 r.p.m.
8-in. stroke	300 r.p.m.
10-in. stroke	285 r.p.m.
12-in. stroke	270 r.p.m.
14-in. stroke	245 r.p.m.

For direct connected electric driven duplex or angle type compressors of up-to-date design:

10-in. stroke	300 to 360 r.p.m.
12-in. stroke	277 to 300 r.p.m.
14-in. stroke	257 r.p.m.
16-in. stroke	225 r.p.m.
18-in. stroke	200 r.p.m.
20-in. stroke	180 r.p.m.
24-in. stroke	163½ r.p.m.

Capacity and Pressure

Conforming with the standardization of speed, the size of compressor has been about the same for the past few years. Capacity may vary per unit from a few cubic feet up to 5000 cu. ft. per min. and sometimes larger. Where larger capacities are required, or where

an uninterrupted supply is essential, the compressor plants should be divided into two or more separate units

For gage pressures below 60 lb. per sq. in., single stage compressors should be employed, except in extra large units. Whether to use single stage or two stage between 60 lb. and 100 lb. depends on the capacity required, the cost of power and the altitude at which the machine is to work. It is generally recognized that multi-stage compressors should be used for permanent installation for pressure of 100 lb. or more, with displacements of 300 cu. ft. per min. or more. Discharge gage pressures of 80 to 125 lb. are considered standard for two-stage compression.

Pressures, of course, depend on the work to be done. For shop tools and rock drills 100 lb. is standard, although the tendency is to carry 110 to 125 lb. at the

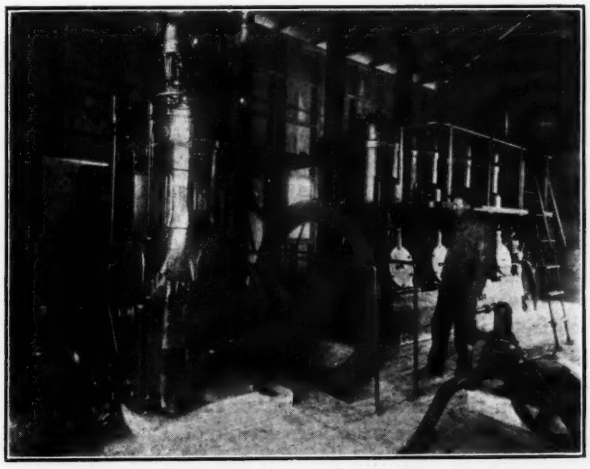


FIG. 1. ANGLE COMPOUND AIR COMPRESSOR DRIVEN BY DIRECT CONNECTED DIESEL ENGINE, AN ARRANGEMENT THAT IS BECOMING MORE COMMON

compressor to take care of drop in pressure in pipe lines.

Type of Drive

While the majority of installations are electric driven there is quite a field for steam and oil engine driven compressors. The pendulum which swung so far towards the electric drive during the times of high priced coal and coal strikes with consequent interruptions of fuel supply is now swinging back to the steam driven compressors, especially in the northern section of the country where heating is required 8 mo.

Diesel engine driven compressors are gaining ground wherever coal or electric power is expensive.

Electric drive is, however, still the favorite and the tendency is toward the direct connected synchronous motor-air compressor combination. Foundation and floor space are always less with the direct connected unit as compared to belt drive. Then there are other savings as the following tabulations will show. In making the following comparison on types of drives, the power is figured at 1½ cents per kilowatt-hour, and the life of a belt at 5 yr. It is assumed that a year consists of 300 days of 8 hr. and that the load factor is 60 per cent.

Increase in first cost justified is based on 15 per cent per year to cover interest, depreciation, etc.

Capacity cu. ft. per min.	Savings per Year	Increase First Cost Justified	Actual Difference in first cost
400	$100.00	$ 700.00	$550.00
900	180.00	1200.00	400.00
1300	210.00	1400.00	75.00

The value of careful installation of compressors is being more and more generally recognized. Plenty of light and ample room should be provided for cleaning and inspection. In foundries, wood working plants and so forth, where there is excessive dust, the air compressor should be located in the main engine room and, where this is not possible, in a dust tight room with provisions made for drawing clean air from the outside to the compressor intake, or an air filter installed.

Lubrication

Lubrication still remains one of the most important considerations in the operation of an air compressor. The best oil should be used and in the amount shown in the table below. This table is the recommendation of the Compressed Air Society and refers to air cylinder lubrication only.

Cyl. Dia.	Displacement	Rubbing Surface	Oil Feed Drops per min.	Pints per 10 hr.
Up to 6 in.	Up to 65 cu. ft.	Up to 500 sq. ft.	1	.05
6 to 8 in.	65 to 125 cu. ft.	500 to 750 sq. ft.	1	.08
8 to 10 in.	125 to 225 cu. ft.	750 to 1100 sq. ft.	1	.11
10 to 12 in.	225 to 350 cu. ft.	1100 to 1500 sq. ft.	1 to 2	.14
12 to 15 in.	350 to 600 cu. ft.	1500 to 2000 sq. ft.	2 to 3	.20
15 to 18 in.	600 to 1000 cu. ft.	2000 to 2600 sq. ft.	3 to 4	.27
18 to 24 in.	1000 to 1800 cu. ft.	2600 to 3600 sq. ft.	4 to 5	.36
24 to 30 in.	1800 to 3000 cu. ft.	3600 to 4800 sq. ft.	5 to 6	.48
30 to 36 in.	3000 to 4500 cu. ft.	4800 to 6000 sq. ft.	6 to 8	.60
36 to 42 in.	4500 to 6500 cu. ft.	6000 to 7500 sq. ft.	8 to 10	.74
42 to 48 in.	6500 to 9000 cu. ft.	7500 to 9000 sq. ft.	10 to 12	.90

The amount of oil shown in the table should not be exceeded, since excessive lubrication causes carbon.

Unloading Systems

Two principal methods of unloading constant speed electric driven compressors, the step and the total closure unloader types, continue to be the favorites, although the automatic start and stop method may gain during the year. The latter type is controlled by a pressure switch which through relays starts the motor when the terminal air pressure falls, and stops the motor when the pressure rises to a predetermined point.

Diesel engine driven compressors are, of course, run at constant speed, and are governed usually by a total closure unloader on the compressor in conjunction with a constant speed governor on the engine. The loading of the air compressor must be delayed so that the engine may accelerate to avoid stalling the unit.

Steam driven compressors continue to use a variable speed combination air and steam governor, the speed of the unit varying to suit the demand for air. During the past year, however, several installations of steam driven machines have been made with constant speed governor on the engines with total closure unloaders on the air end. It is claimed for this system that the steam consumption of the engine is better, since the steam cylinder keeps hotter, and there is less chance for leakage, due to the fact that the piston is moving at high speed all the time.

Due to the improvement in air cylinder designs, steam engine driven compressor speeds have been increased so that, if anything, the speed at which the steam end can be operated determines the speed.

EDITORIAL COMMENT

Coal and the Chemist

No raw material is of greater importance in the world at the present time than coal, particularly bituminous coal. Ordinarily thought of as a prosaic substance, necessary because of its heat-giving qualities, but never to be regarded as having anything to do with the dreams of romantic idealists, coal, in the mind of the ordinary mortal, is just coal, nothing more. The power plant engineer presents a more intelligent attitude, perhaps, but even he is likely to regard it as a necessary item of expense to be kept as low as possible by good combustion efficiency.

In the mind of the chemist, however, coal is something more than a mere fuel, for the chemist really knows what coal is. He uses a block of coal as a seer does a crystal, peers into its structure and sees a magic world illuminated by the sunshine of by-gone ages. A professor in a German theological school not many years ago explained the alarming decline of public morals by saying that when God separated light from darkness on the second day of creation, he buried the darkness in condensed form in the bowels of the earth but since men have incautiously lifted the lid from the coal beds the darkness thus released from prison has generated and set fire all manner of devilish lusts like drunkenness and debauchery.

This is a new argument for coal conservation but a poor one. Coal, contrary to being stored darkness, is in reality stored sunshine. As pointed out by Dr. Slosson at the recent Bituminous Coal conference in Pittsburgh, the unprecedented prosperity of the present time is due to the sudden release of the accumulated savings of energy received from the sun 250 million years ago.

In coal, the chemist of today sees a synthetic world built up of atoms of carbon—at once the most precious of substances as in the diamond and also the most valuable as in coal. Combined with hydrogen, nitrogen and oxygen, the carbon atom is capable of producing not only all the innumerable compounds of animal and vegetable life but also the 400,000 compounds of carbon listed in Beilstein's dictionary, of which only a small proportion are to be found ready formed anywhere in the three kingdoms of nature.

Of this synthetic world the chemist is king. At his command the carbon atoms, together with those of N, O and H, line up and form into squads to do his bidding. In one case their line-up spells oil; in another gas, in still another dyes, perfumes or drugs.

With this aspect of coal, i.e., its conversion into other products, the power plant engineer has little to do. His interest in coal is primarily as a fuel, but to know something about its other properties and possibilities certainly will not harm him. While raw coal is an excellent fuel, it is not the most desirable way to burn it. When carbonized, both the gases produced and the coke are more satisfactory from a combustion standpoint and when liquefied by the Bergius process, all the advantages of fuel oil are obtained. As long as coal is still plentiful, it is doubtful whether carbonization or liquefaction will be used to a large extent in this country but ultimately these processes will become desirable.

Highway Lighting as an Electric Load

Accustomed as we are to thinking of electricity as the most desirable lighting medium, it is somewhat of a surprise to learn that 80 per cent of the Paris lighting system is composed of gas installations. In fact, the most recent boulevard lights use gas even though the advocates of electric street lights say that rapid progress is being made with electric systems.

Gas street lights have not, of course, disappeared entirely in this country, although installations using artificial gas would no longer be considered for new projects. Considering the casual thought given to gas lights in this country, it is rather amusing to read of a recent meeting of the Association of Public Lighting Engineers of England where it was pointed out that:

"Street lighting with lamps placed on one side only is dangerous. The standard lamp in use throughout the country is rather on the short side because it clashes with the shop window lighting in many instances. Most of the motorists who travel much at night complain of certain towns and villages with upright mantles, many of them broken and the lamps out of order and in many cases even flat flame burners in use. From the motorist's point of view, they would be much better left out altogether."

Possibly the unfortunate impression of the motorist is responsible for the frequent changes from gas to electric lighting even in England. In this country street lighting has been extended to highway lighting and, although most of the advance work to date has been carried on by manufacturers of equipment, the move is receiving more widespread support on the ground of greater safety and increased care of the highway.

Recently, an experimental installation was made over a two-mile stretch of highway near Neoga, Illinois. Electric lamps are spaced so that the light is evenly diffused over the length and width of the illuminated section of the road. Efforts are being made by various organizations in all parts of the state, notably in Cook County, to have all state highways completely lighted.

Widespread use of highway lighting should be a benefit to the electric power industry in two ways; first, it will add a desirable load and second, it will extend transmission lines and should be an important aid in rural electrification.

Off Duty

Some seventy years ago, at a time when the black tornado of civil war was sweeping the land and the young and strong were being sucked into its path from all parts of the country, there was born on the frontiers of Minnesota a boy who was named Frederick Russell Burnham. Minnesota, at that time, was a wilderness infested by the hostile Sioux. Emboldened by the depleted state of the settlements and stung by repeated deceptions at the hands of the whites, they made the life of the pioneers one of constant peril. More than once, the baby Frederick fell asleep to the ping, ping of Indian bullets against the logs of the pioneer cabin.

Frederick was not destined to be scalped, however, for several years later, due to the ill-health of the father, the family migrated to southern California where nature was bountiful and boundaries dim. Here the lad spent a colorful boyhood and at 13 became a mounted messenger for the Western Union Telegraph Co. The country left a vivid impression on his mind—underneath the golden atmosphere of ease there appeared a recklessness, a spirit of high adventure which he sensed but could not explain. Here, too, his fancy was stirred by the daring exploits of the bandit Vasquez.

At 16, after a short period of schooling with an uncle in the Middle West and against which the boy rebelled, we find him on a great river one dark night, headed for the plains—the Southwest and freedom.

With a ruling passion for life in the open, no charm could hold the boy long against the lure of New and Old Mexico and Arizona, then fascinating regions on the outskirts of civilization. Here, under expert tutelage, he learned the right and wrong ways of performing the simplest tasks—putting on or taking off a saddle, tying a knot, making a bed, protecting oneself from snakes, how to double and cover trail, how to travel in the direction intended, how to find water in the desert. Holmes, a man who had served under Kit Carson and Fremont, gave him his first lessons in scouting.

So it is that while still in his teens we find Burnham, a thread woven into the strange and intricate pattern that made up the fabric of life in Arizona and Mexico in those days, engaged in high adventure—sometimes roaming the arid deserts and mountains prospecting, now drawn irresistibly into the feuds between the cattle and sheep men of the open range, again scouting in dangerous Apache territory—always running the gauntlet between life and death. Life was cheap and feeling ran high. The Apaches were known as the wariest of all American Indians and scouting among them required courage, skill, strategy and endurance to a high degree but Burnham possessed these qualities in abundance. His escapades in this land were hair-raising. Bitter and determined enemies pursued him for months at a time. Under the suffocating heat of the desert or in the bitter cold of a Texas blizzard, he was equally at home. Yet, as one who bore a charmed life, he came through unscathed and in his middle twenties we find him happily married, the owner of a pleasant orange grove in Pasadena.

But civilization was not for Burnham's roving nature and soon he, together with his courageous wife and small son, were entering the vast wilderness of South Africa, for Burnham was intrigued with the name of Cecil Rhodes. How they made their way through hundreds of miles of unknown wilderness, infested by wild animals and poisonous snakes, through lowlands where lurked fever and disease, across rivers filled with crocodiles forms a narrative of absorbing interest, yet for Burnham this adventure was only a means to an end. For he was here to join Cecil Rhodes and later on rode deep into savage territory to slay the M'Limo, the treacherous Matabele high priest.

His thrilling exploits in carrying despatches through the wilderness, his expedition to Bulawago, the mysterious unknown capital of Matabeland, his dash to capture Lobengula, the native king, and his subsequent participation in the golden age of Rhodesia, one would think would satisfy the adventurous longings of any man, but it did not Burnham's, for in 1897 he is off for the Klondike gold fields.

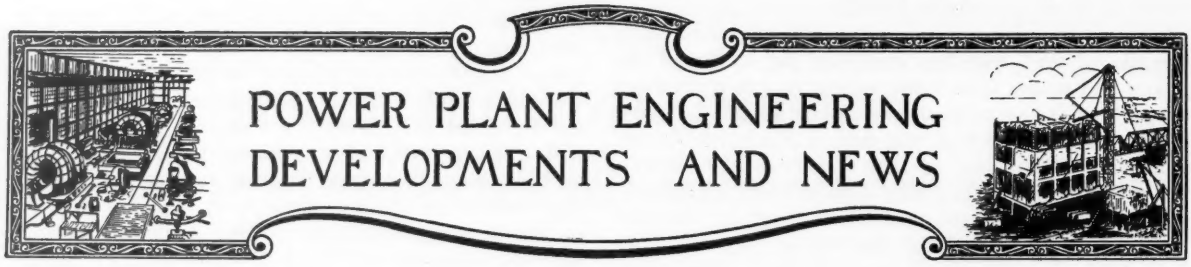
In the frozen north, his knowledge of scouting and his years of experience in the outdoors served him in good stead and from his claim he, together with one, George Burke, in '98 took one hundred pounds' weight of gold nuggets back to England—the first actual gold of the Klondike that was to pour its flood for so many years to come. But the lure was strong and in '99 he was back again and remained until the rumors of Boer War in South Africa reached him. He had already started for Africa when the cable reached him, appointing him Chief of Scouts under Lord Roberts.

His work in the Boer War was, perhaps, the most thrilling of all his exploits and after it was over, the British Empire showered upon him her highest honors. Not only was this American awarded the cross of the Distinguished Service Order but King Edward confirmed his rank as Major in the British Army without requiring him to renounce his American citizenship.

The fame of Major Frederick Russell Burnham is little known in America. He was well known to Roosevelt, Richard Harding Davis, John Hayes Hammond and other prominent Americans who greatly enjoyed his company, but the public knows little of him. In this brief article, we have but touched upon a few incidents in this remarkable man's life. Nothing has been said of his exhausting Ashanti expedition to the African gold coast or his explorations around Lake Victoria nor of his Mexican explorations.

It is with the hope of acquainting some of our readers with the amazing accomplishments of this man that we direct attention to a book, "Scouting on Two Continents," which contains the story of Burnham's life. Those of us whose fate it is to publish technical magazines or run or build power plants or are otherwise engaged in pursuits that civilization has thrust upon us, will find in it many an enjoyable hour while off duty. Many of us are still savage at heart, and while it is not in our power to lead a care free existence under blue skies as we would like to, we can forget our cares and worries for a time at least in the hair-raising exploits of Major Frederick Russell Burnham.

IN THE ISSUE of October 1 on page 1032, comment was made by Chas. J. Webb on electric steam generation as used in Switzerland. In this article, Mr. Webb omitted to state that the generators which he described were made by Escher Wyss & Co. of Zurich, Switzerland.



International Bituminous Coal Conference

ANY ATTEMPT to present an account of the proceedings at the Second International Conference on Bituminous Coal held at Pittsburgh, Pa., during the week of November 19 must of necessity be superficial in nature and deal with the work of the conference only in a most general manner. Merely to enumerate the papers presented at the meetings would require considerably more space than is available for this entire report.

A brief history of the conferences may not be amiss. The first International Conference on Bituminous Coal took place at the Carnegie Institute of Technology in 1926 and was the first international meeting of the kind ever held; it marked an epoch in the history of the use of coal. It showed that this commodity, which has been looked upon almost universally as a substance merely to be burned, must be regarded in the future as a raw product which can be transformed into a thousand different and valuable commodities. The motive behind these conferences is a frank desire to help the industry.

In treating the subject of bituminous coal at these conferences, only questions of a scientific or engineering nature are considered. The mining and marketing of bituminous coal is not discussed. The purpose is to present the results of the most recent studies of coal that have to do with improved methods of combustion and utilization.

At the conference which was held last month, scientists and engineers from some 20 nations presented papers on all aspects of the utilization of coal for the benefit of civilization. Not only did these papers deal with coal as a fuel, but also as a possible raw material to be used in the production of other useful materials.

Naturally, at a conference of this type a wide variety of interests are represented. The various papers, therefore, were delivered at simultaneous sessions so arranged on the various days that an engineer interested in say pulverized coal, could attend all the sessions on pulverized coal since all of these sessions were held successively. The simultaneous sessions were of a widely different character.

The conference was formally opened by Dr. Baker, president of Carnegie Institute of Technology, at a general session on Monday morning, Nov. 19. In this address, Dr. Baker indicated the great importance of coal as a fuel and also its fundamental significance as a factor in the wealth and prosperity of the nation. At this session, papers were also delivered by Dr. Cecil H. Lander, director of the Fuel Research Board of London, and by Dr. Carl Krauch, director, I. G. Farbenindustrie Aktiengesellschaft, Ludwigshafen am Rhein. Dr. Lander recounted the work of the British Fuel Research Board during the past year while Dr. Krauch discussed the conversion of hydrocarbons by means of catalysis. He described the technical difficulties which had to be overcome in developing processes for the catalytic hydrogenation of hydrocarbons, and referred briefly to the plant which the I. G. now has in operation, where the present annual production of 70,000 t. of gasoline will be increased by the end of this year to 250,000 tons.

Coal Hydrogen and Capital

An extremely interesting paper presented at the second general session on Tuesday morning, at which Samuel Insull presided, was that on Coal Hydrogen and Capital, by F. zur Nedden of Berlin. Dr. zur Nedden directed attention to the fact that coal, oil and gas consist of chemical combinations of hydrogen and carbon or hydrocarbons. The tendency of the "energy markets," he said, favors pure and concentrated hydrocarbons. This explains the large increase in the consumption of oil and gas in the United States and the impetus toward artificial coal improvement in Europe. In this connection, he referred to the capital requirement for the improvement of coal. The higher the quality of the fuel into which coal is transformed, the greater is the amount of capital investment required per ton of annual through-put of coal. Coal improvement has, therefore, a decided tendency to occupy capital.

Capital, said Dr. Nedden, may be characterized as frozen wages. When capital is invested, i.e., when plants are built, it melts into wages again, thus stimulating the whole of industry.

Much Interest in Pulverized Coal

Of particular interest to the power plant engineer were the three sessions on Pulverized Coal and the four on Power and Combustion. At the first, much interest was exhibited in the paper describing an internal combustion engine for powdered coal, by **Rudolph Pawlikowski**, of the "Kosmos" Machine Works, Gorlitz, Germany. This paper, because of the author's inability to come to the conference was read by Professor Trinks of Carnegie Institute. The engine described has been in operation, under industrial load conditions, for a number of years and has operated satisfactorily on many kinds of pulverized coal. It is built much along the lines of a regular Diesel engine and no particular difficulties seem to be encountered with ash. The success seems to be due in a large measure to the use of very fine pulverized coal.

Probably no paper presented at the conference held as much significance to the power plant engineer, nor was based on a more thorough scientific research than that given by Dr. P. Rosin, of Dresden, on the Thermodynamic Basis of Pulverized Coal Combustion. Dr. Rosin has developed a series of equations whereby the heat release, the speed of combustion reaction and the physical characteristics of the coal for any desired condition can be predicted. He indicated that the time of combustion reaction, that is, the rate of combustion per unit volume, is determined largely by the aerodynamic conditions in the furnace. Investigations show that burning periods of a few tenths of a second can be attained and therewith loads which are many times greater than the customary present day ones. It is a question of fine grinding and relative velocity between the coal particles and the air necessary to effect complete combustion. In practice, however, it is found that as the size of the particles is decreased the relative air velocity is decreased. In the turbulent burner of today the relative velocity of air and coal is considerably greater than in the older methods of burning pulverized coal, but as Dr. Rosin pointed out by means of his calculations, we are still far from the theoretical limits of combustion reaction.

Henry Kreisinger, research engineer of the Combustion Engineering Corporation, also stressed the importance of intensive mixing of the pulverized coal particles and the air for their combustion. Mr. Kreisinger showed why pulverized coal is more difficult to burn than either gas or oil, basing his proof upon its more complicated physical and chemical structure.

Pulverized Coal Lends Impetus to Stoker Progress

At this same session, Jas. W. Armour, vice president of the Riley Stoker Co., Worcester, Mass., described the recent advances made in the design and application of stokers. He discussed the competitive influence of pulverized coal as a factor responsible for improved stoker design and pointed out that where modern stokers are used with furnaces similar to those used with pulverized coal, the efficiencies of the respective systems are about equal.

This point was also brought up by R. J. S. Pigott in a discussion of Prof. Christie's paper on Boilers for Bituminous Coal. Mr. Pigott stated that stoker manufacturers are no longer content to accept any conditions of furnace design imposed upon them, and that where furnaces of modern design are used with stokers, the efficiency approaches the higher efficiencies of pulverized coal practice to a close degree. Whereas stokers formerly were of from 3 to 4 per cent lower efficiency than powdered coal installations, today, with the proper types of furnaces, they come to within one per cent of the efficiencies obtainable with pulverized coal.

Adaptation of pulverized fuel to marine boilers was the subject of a paper presented jointly by C. J. Jefferson of the U. S. Shipping Board and Commander J. J. Broshek of the Fuel Oil Testing Plant, U. S. N. This paper, although of direct interest to marine engineers, should also be of interest to men operating small stationary plants because the conditions in marine work are often similar to those existing in the small stationary plant. This paper showed how the rate of evaporation in Scotch marine boilers had been increased from 3½ lb. per sq. ft. of heating surface to 8 lb., while the boiler efficiency increased from 54 per cent to over 79 per cent.

If any one thing was brought out more clearly than another at these pulverized fuel sessions, it was the fact that in burning pulverized fuel, the entire problem is to bring the particles of coal in contact with the necessary air for combustion as rapidly as possible.

Power and Combustion Sessions

At the Power and Combustion sessions, a number of papers were presented which dealt with a variety of subjects. Several took up the ash problem, discussing methods for determining its melting point, its removal from the furnace and its effect upon economy. Other papers on boilers and furnaces outlined the requirements of furnaces and boilers for efficient combustion. Still others were concerned with questions of conservation in both the power and heating field. Among the papers of interest discussing the latter subject, was one by A. R. Smith of the General Electric Co. Mr. Smith stated that the theoretical heat energy available with 1200 lb. steam pressure and 700 deg. F. initial conditions and with 1 in. Hg. absolute final condition in a regenerative reheat cycle is approximately 47 per cent. With the binary vapor cycle, using mercury vapor, however, an efficiency of 60 per cent may be obtained, a decided increase, well worth taking advantage of. Mr. Smith also discussed the use of combination steam power and gas plants as a means of obtaining higher thermal efficiency, all of which was of considerable interest.

D. S. Jacobus, advisory engineer of the Babcock and Wilcox Co., together with E. G. Bailey, president of the Fuller Lehigh Co., presented a paper on the removal of ash and loss of carbon from boiler furnaces, which was received with considerable interest. Mr. Bailey, who delivered the paper, showed the influence of fineness of pulverization upon the carbon loss and ash production, and presented considerable data on modern methods of ash removal.

Among the features of general interest at the conference was the evening session on Tuesday, at which Dr. Slosson gave a lecture on the Synthetic Kingdom and the Conference Dinner on Thursday evening at the Hotel Schenley. At the latter event, many foreign celebrities in the world of science addressed the conference. Among the speakers at this dinner were Georges Claude of Paris, E. C. Evans of Great Britain, Dr. Fritz Hoffman and F. zur Nedden of Germany, S. W. Parr and Dr. Slosson of the United States and Dr. Bing of France.

The entire conference was unusually well organized and proceeded without confusion or misunderstanding. All the sessions were in charge of competent men and while discussion was invited it was limited as to time so that all who desired might have an opportunity to present their opinions. A number of the most important papers will be abstracted in future issues.

Cutler-Hammer Mfg. Co., 12th and St. Paul Ave., Milwaukee, Wis., announces that on December 1 its Atlanta office moved into new quarters at 150 Peters St., S. W., Atlanta, Georgia. A. C. Gibson is manager in charge of the Atlanta office.

Elmer A. Sperry, Originator

AERIAL, CHEMICAL, ELECTRIC, MARINE AND MINING INVENTIONS ARE TO HIS CREDIT

PIONEERING,—what is the urge that drives men from comfortable, beaten paths to seek the untried? Be it the ambition to know and do what no man has known or done before or revolt against conditions felt to be irksome and hampering, the result is the same—a driving toward new fields to conquer in territory, industry or knowledge. Blazing new trails is in the pioneer's blood. He must go forward.

ELMER A. SPERRY, PRESIDENT, A. S. M. E.

From a line of pioneering ancestors, Mr. Sperry inherited this urge. Down the line, from Richard Sperry, who came to the New Haven Colony in Connecticut in 1634, and afforded protection to men who had condemned Charles I of England to death, the line is of strong men and women, always pushing forward the frontiers of human activity.

Elmer A. Sperry, born in 1860, although having training in the State Normal School and one year at Cornell University, followed his own bent in gaining special knowledge. When not yet 20 yr. old, he had started invention with a new method for arc lamp control. During his twenty-first year, he is found pioneering in the manufacture of arc lamps, dynamos, motors and electrical equipment by his own company, the Sperry Electric Co. of Chicago. This was a forerunner of companies organized to manufacture his inventions of which six large corporations were operating by 1910.

High lights of his pioneering (no pun intended) were an electric beacon of 40,000 c.p. on a tower 350 ft. high, electric machinery for mining, including reciprocating and rotary cutters and locomotives, electrical street cars and equipment, electric motor cars and the like.

Some 30 yr. ago, Mr. Sperry conceived that the gyroscope, instead of being only a curious toy, was capable of important service. Others have also tried but to Mr. Sperry alone was given the pioneering perseverance to solve the problems of successful development. Results: The gyro compass, standard equipment for all naval vessels and the foundation of naval gunnery control; the ship stabilizer for preventing roll, to steady the naval gun platform and increase comfort and economy of operation of passenger boats; control of air craft by stabilization and drift indication which permits of flying in fogs and darkness.

And to dispel darkness, he broke away from tradition and developed a new high-intensity arc light having 600 per cent of the brightness before obtained from the brightest light possible.

Better quality white lead at low cost from copper mine waste is due to an electrolytic process of Mr. Sperry's devising. Caustic soda and electric battery manufacture were improved by his methods. Air craft bombing control, torpedo control and propulsion are among the 400 patents to his credit.

Yet, with all this activity, he is a man who has found time to work sympathetically with his fellows for the advancement of humanity and his profession of engineering. He brings to the presidency of the American Society of Mechanical Engineers, experience, judgment and organizing ability from nearly 50 yr. of scientific, engineering, industrial and executive activity; a wide acquaintance with engineers in all branches of the profession and a full realization of the functions which a society may perform to benefit its members and humanity.

83,333 Kv-a. Concentrated in One Transformer

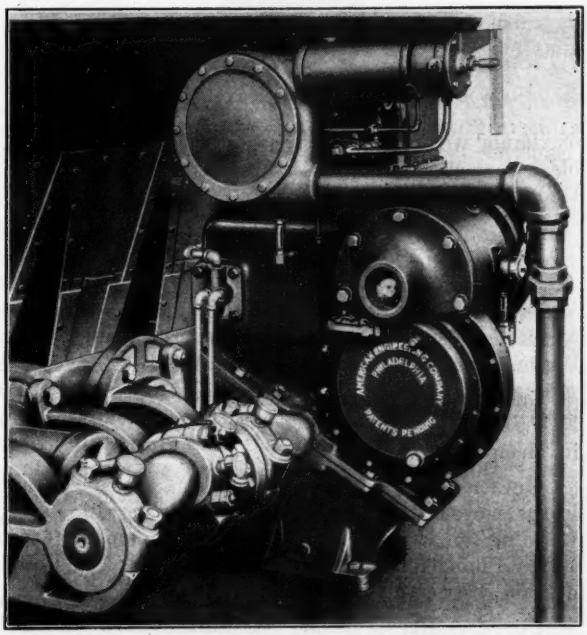
PROBABLY THE maximum output ever concentrated in one transformer unit is represented in the 83,333-kv-a. auto-transformer which has been built at the Pittsfield works of the General Electric Co. for use in the Charles R. Huntley station of the Buffalo General Electric Co. The unit is rated three-phase, water-cooled, 25 cycles, 83,333 kv-a. output, 24,500Y-12,000Y v. Based on its equivalent transformer capacity of 49,200 kv-a., it required parts that could be used in building a 60-cycle, two-winding transformer rated at about 100,000 kv-a. at the same voltage.

Occupying a floor space of 23 ft. by 14 ft., this transformer stands 14 ft. over the top of the cover. It weighs 115 t. and, when filled with the necessary 13,300 gal. of oil, weighs 165 t. The core alone weighs 58 t. The conservator tank, which holds more than 1000 gal. of oil, is 192 in. long and 40 in. in diameter. A mile and a half of copper cooling coil is arranged in four layers and 20 sections, with 20 inlets and 20 outlets. When operating at full load, the transformer requires 190 gal. of water per min.

The high voltage or series winding consists of two separate circuits, each of which is connected to a separate section of the station bus. Such an arrangement limits the current that can flow during a short circuit on the system. Each circuit is designed to carry not only half the total load, or 41,667 kv-a. but also, under unbalanced conditions, a maximum of 55,000 kv-a. with the load on the other circuit not exceeding 28,333 kv-a. Instead of the standard three-legged core, use is made of the five-legged core to keep the height down to a minimum and to facilitate end-sheeting during assembly.

Terry Steam Turbine Drive for Stokers

TO PROVIDE a stoker drive that will vary coal fed by the stoker to correspond with comparatively small variations in boiler load, the Terry steam turbine stoker drive shown herewith has been developed. It consists of



TERRY STEAM TURBINE DRIVE MOUNTED ON TAYLOR STOKER

a small steam turbine with suitable reduction gearing, throttle control being designed to make available a 10 to 1 range in speeds with every intermediate speed for the stoker as a whole, to meet the exacting requirements of automatic control systems.

The drive is shown here as mounted on a Taylor stoker, the turbine being combined with the upper part of the stoker power box to form a compact unit. The entire driving system is enclosed but the turbine can be easily detached for inspection.

Speed reduction from the turbine to the stoker speed shaft is by helical gearing and silent chain drive. The silent chain pinion has roller bearings and thrust bearings to take up the end thrust of the helical gears, which run in an oil bath.

Turbine shaft bearings are supplied with lubricating oil under pressure by a geared pump driven by an auxiliary silent chain drive from a pinion integral with the main pinion. The oil supply is housed in a cored and painted space in an extension to the power box. Cooling coil completely screened and special suction pipe inside the cooling coil are used to assure a continuous supply of clean, cool oil for the pump suction.

Steam used by the turbine can be exhausted for process work or heating. This new stoker is a product of The Terry Steam Turbine Co., Hartford, Conn. It is stated that American Engineering Co., of Philadelphia, has been one of the first to apply the drive to the Taylor stoker as shown above.

Cochrane Announces Improved V-Notch Weir Recorder

TO RECORD the flow over a V-notch weir on a chart having uniform graduations, it is necessary to use some form of rectifying mechanism. At first thought, it might seem a simple matter to attach a cam directly to the float stem so that it would push the pen sidewise the correct distance as the float rose. Due to the fact, however, that the flow over a V-notch increases as the 5/2 power of the head, such a cam would become extremely steep at the high flow end and there would be a tendency for it to bind.

The new Cochrane V-notch recorder, shown herewith, is intended to solve this problem. The cam is hung from pivot bearings and oscillates in a vertical plane, while a roller carried by the float stem and moving up and down in a straight line bears against the edge of the cam, approaching the axis or center of oscillation of the latter at the higher flows. This disposition of the parts is intended to get the required transformation of motion with a cam of comparatively simple form, for as the roller approaches the center of oscillation its

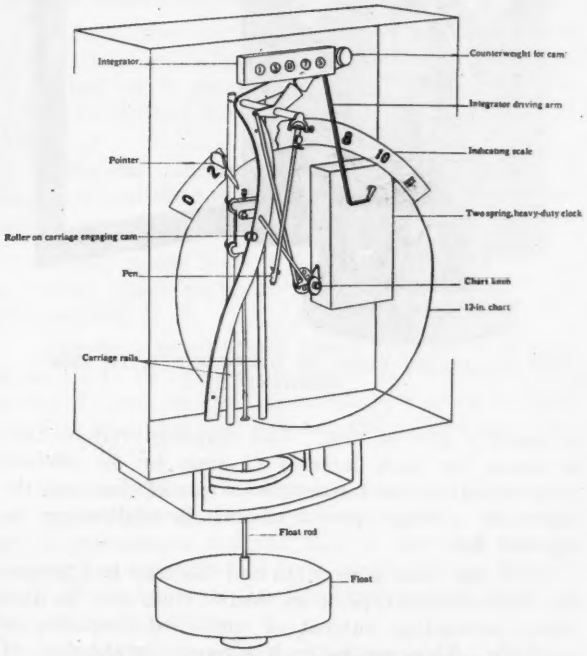


FIG. 1. DIAGRAM OF WORKING PARTS

effect in moving the cam angularly is increased, just what is required to accommodate the 5/2 power law. A slight biasing weight on the cam keeps the latter always in contact with the roller.

The pen arm is attached directly to the cam spindle, while the visible pointer is mounted on a separate spindle connected to the cam by a link motion. The operation of the integrator is controlled by motion received through a pair of toothed sectors. The positive, direct drive from the float to the recorder pen is provided to eliminate slack or back-lash and to prevent rapid up-and-down movements of the float from putting the instrument out of order.

The integrator is of the clock-driven type, designed

to impose no restraint upon the flow measuring parts. The gear train consists of spur gears, each pair having a ratio of 10 to 1. There is one tooth on the pinion and 10 teeth on the gear. This one pinion tooth engages for only a part of a revolution, the gear being held stationary during the remainder of the pinion revolution, as the remainder of the pinion has no teeth but is circular and bears between two adjacent teeth of the gear. The result is that two adjacent teeth of the gear, except the first or highest-speed gear, advance always a whole number at a time. Except for the first dial, there is, in other words, no gradual, continuous movement of the figures, as would be the case were an ordinary gear train used.

Now, the first, or highest-speed, gear is advanced by varying small increments which are proportional to the momentary rate of flow. The counting train is thus advanced for each interval of time by an amount proportional to the instantaneous rate of flow and the result for a longer period of time is totalized or integrated flow.

FIG. 2. FRONT VIEW OF RECORDER WITH CHART REMOVED

Only one clock is required and this may be a powerful double-spring type or an electric clock may be used where alternating current of controlled frequency is available. This new meter is a recent development of the Cochrane Corp., Philadelphia, Pa.

Improved Outlet Box

FOR USE with metallic cable, non-metallic sheathed cable or loom a new outlet box with reversible clamp and bushing plate for side or bottom knockouts is announced by the Chicago-Jefferson Fuse & Electric Co., 1500 South Laflin Street, Chicago. The feature of the new box is the unique type of clamp which is reversible, so that the cable may be brought in from either the side or bottom knockouts.

It is designed in such a manner that the holes are completely closed, conforming to Underwriters specifications. The clamp is provided with bushed holes and eliminates the necessity for the bushed flange plate such as furnished on the 1289X Box or a brass ferrule. It is so compact that it permits the use of any type fixture stud and hickey in the smaller 3¼-in. box and permits maximum wiring space. The box is finished in either black enamel or galvanized and is listed as standard by Underwriters' Laboratories.

NEW OUTLET BOX WITH REVERSIBLE CLAMP

News Notes

JEFFREY MANUFACTURING CO., Columbus, Ohio, has recently appointed Stanley M. Mercier manager of its Boston office, 141 Milk St., Boston, Mass.

GRISCOM-RUSSELL CO., 285 Madison Ave., New York, N. Y., announces that it has opened a new branch office in Memphis, Tenn.

MCCLAVE-BROOKS CO., Scranton, Pa., announces that it has moved its Philadelphia office from 610 Morris Building to Room 913, Fidelity - Philadelphia Trust Bldg., Philadelphia, Pa. George Blain, Jr., is Philadelphia district manager.

BOTFIELD REFRACTORIES CO., Philadelphia, Pa., announces that the Marshall Supply Co., Inc., operating in Pittsburgh, Kansas and Tulsa, Oklahoma, has been appointed distributor of Botfield Refractories products.

RILEY STOKER CORP., Worcester, Mass., announces that James W. Armour has been made vice president of the Riley Stoker Corporation. Mr. Armour still retains his title of engineering manager.

NATIONAL FLUE CLEANER CO., Inc., Groveville, New Jersey, announces the appointment of the following sales representatives: Graun-Liebing Co., Cleveland, Ohio; Dennis Engineering Co., Columbus, Ohio; Bishop Engineering Co., Cincinnati, Ohio; Power Plant Efficiency Co., Indianapolis, Ind.; Rathburn Co., El Paso, Texas.

STONE AND WEBSTER, INC., Boston, Mass., announces several personnel changes in its organization. Walter H. Burke has resigned as district manager of the companies under the executive management of Stone & Webster, Inc., in the southwestern district and is returning to the east. Effective January 1, 1929, James F. McLaughlin has been appointed to succeed Mr. Burke. Tom P. Walker, vice president of Virginia Electric and Power Company, is to be transferred from Norfolk to Richmond, and beginning December 1, 1928, will be in charge of all operations of the company, succeeding Mr. McLaughlin. Joseph Bowes, formerly manager of the El Paso Electric Co., El Paso, Texas, will assume charge of the Norfolk Division on December 1. Francis J. Gannon, formerly assistant treasurer and secretary of the Davis Islands, Inc., has been appointed manager of the El Paso Electric Co. and associated organizations.

PENNSYLVANIA PUMP AND COMPRESSOR CO., Easton, Pa., has appointed as sales representatives J. F. Rodgers, 726 Oliver Bldg., Pittsburgh, Pa., and Gustavo Preston, 113 Broad St., Boston, Mass.

TIMKEN ROLLER BEARING CO., Canton, Ohio, announces that it has completed expansion of its production facilities, necessitating the expenditure of about $6,000,000 during the current year.

W. B. MARSHALL has been appointed sales manager of the contract engineering department of the Chain Belt Co., Milwaukee, Wis.

ANNOUNCEMENT HAS recently been made of the death of Walter J. Kline of the American District Steam Co., North Tonawanda, New York, on Saturday, November 17.

ACCORDING TO a recent announcement of the Board of Directors of Fairbanks, Morse & Co., Chicago, Illinois, John A. Manley, for the past three years engineer of sales development, has been elected vice-president in charge of sales. Mr. Manley was formerly manager of accounts for the advertising agency of Henri, Hurst & McDonald of Chicago. In connection with his advertising work, Mr. Manley made a detailed study of the problems of industrial business development and it was the result of this work that brought him into the Fairbanks, Morse organization. He is a graduate of Northwestern University in the class of 1911 and also served for four years in the sales department of the Republic Tire and Rubber Co.

CONSOLIDATED ASHCROFT HANCOCK CO., INC., announces the removal of its Chicago office to 605 West Washington Blvd., Chicago, Ill., on November 15. This office will also house the staff of the American Schaeffer & Budenberg Division, recently consolidated with the above. G. A. Binz, formerly sales manager of American Schaeffer and Budenberg Corp., has been appointed sales manager in charge of the western industrial division with headquarters in Chicago. The western division will handle the business of the company in that part of the United States and Canada west of a line drawn from Toronto, Ontario, to New Orleans, La. The company requests its customers and prospects in this western section to direct all future correspondence to the above Chicago address. Complete stocks of the company's equipment will be carried at Chicago and a central repair and service department has also been established in charge of a competent engineer.

IN THE APPLICATION of the Alfit Packing Co., Inc., to the New York County Supreme Court for an injunction to restrain the Alfit Manufacturing Co., Inc., from selling packing under the name Alfit, the ruling was made that upon consideration of all papers presented before the court the plaintiff had failed to establish its right to an injunction and the application was denied. This leaves the Alfit Manufacturing Co., Inc., free to market its Alfit all-metallic packing.

JOHNS-MANVILLE CORP. has purchased, it is announced, the entire line of products of the Celite Products Co., covering an annual business of $4,000,000 in diatomaceous earth insulation and kindred lines, also the assets which include the Celite holdings of the fossilized sea life deposits in California. It is reported that the business will be developed and amplified by the new owners.

Catalog Notes

TEXROPE DRIVES, their advantages and applications, are discussed in detail in a well-illustrated 16-page bulletin, No. 1228-H just issued by Allis-Chalmers Manufacturing Co., Milwaukee, Wis. The company is also issuing bulletin 1118-E, describing type AR and ARY polyphase induction motors with sleeve or tapered roller bearings.

U-RE-LITE all-steel distribution groups for industrial use are described in bulletin 220 by I-T-E Circuit Breaker Co., Philadelphia, Pa. Discussion and illustrations show how the power and light circuits are given automatic protection without fuses, how all the live parts are safely encased in steel and other interesting features of the equipment.

CENTRIFUGAL PUMPS of the multistage single suction type are illustrated and described in a recent bulletin of the Aldrich Pump Co., Allentown, Pa.

WOUND-ROTOR induction motors, high-torque double squirrel-cage motors and outdoor switching equipment are described in a group of bulletins just issued by the General Electric Co., Schenectady, N. Y.

IN THE LATEST ISSUE of the Adsco Advocate, No. 5, Volume 2, is a detailed discussion of expansion joints, where and how to use them. This is a publication of the American District Steam Co., North Tonawanda, New York.

FORCE-FEED lubricators of from 1 to 60 feeds are described and their applications illustrated in a 4-page folder sent out by Hills-McCanna Co., Chicago, Illinois.

ALLPAX in coil form is described and illustrated in a recent leaflet sent out by The Allpax Co., Inc., Mamaroneck, N. Y.

LINK-BELT Silent Chain Drives from stock in sizes from 1.2 to 60 hp. are illustrated and described with tables of dimensions and price lists in a recent bulletin, No. 725, issued by Link-Belt Co., 910 S. Michigan Ave., Chicago, Ill.

HOUGHTO-CLEAN, a compound for general cleaning in office buildings, manufacturing plants, hospitals, hotels, restaurants and the like, is described and its applications are discussed in a recent 36-page bulletin by E. F. Houghton & Co., 3d, American and Somerset Sts., Philadelphia, Pa.

SCHUTTE & KOERTING flow indicators for pipe lines carrying oil, water and other liquids are described in bulletin 6-F, recently issued by Schutte & Koerting Co., Philadelphia, Pa.

EXHAUST STEAM FEEDWATER HEATERS, V-notch meters, barometric surface, condensers, live steam feedwater purifiers and other steam plant accessories are described in detail in catalog No. 90 by the Hoppes Manufacturing Co., Springfield, Ohio.

CENTRIFUGAL PUMPS for all purposes are described in a 6-page illustrated folder by Frederick Iron & Steel Co., Frederick, Md.

WAGNER large RA, single-phase, repulsion induction motors are described in bulletin 157, just issued by the Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.

Power Plant Construction News

Ark., Little Rock—The Arkansas Cold Storage Co. has plans under way for a six-story addition to ice-manufacturing and cold storage plant reported to cost more than $100,000.

Calif., San Francisco—The Empire Development Co., care of H. L. Haehl, Humboldt Bank Building, San Francisco, engineer, has applied for permission to construct hydroelectric power plant on Kern River in Tulare County, with total capacity of 149,750 hp., estimated to cost more than $20,000,000, with power transmission lines and substation.

D. C., Washington—The Potomac Electric Power Co., Washington, has work under way on an addition to its Benning steam-operated electric power plant, to include installation of 30,000 kw. generating unit and auxiliary equipment to cost more than $2,000,000.

Ga., Brunswick—The Mutual Light & Water Co. is planning extensions and improvements in power plant and system, including installation of additional equipment. Company has secured permission to issue bonds in amount of $325,000, a considerable portion of proceeds to be used for the work.

Ill., Chicago Heights—The Public Service Co. of Northern Illinois, Chicago Trust Building, Chicago, has approved plans for a one-story power substation at Chicago Heights reported to cost about $40,000, with equipment. H. VonHolst, 79 West Monroe Street, Chicago, is architect.

Ill., Chicago—The Pines Winterfront Co., 404-24 North Sacramento Avenue, will install power equipment in proposed two-story addition to automobile equipment plant estimated to cost more than $500,000. J. F. Raleigh is president.

Ill., East St. Louis—The Union Electric Light & Power Co., St. Louis, Mo., has work in progress on extensions and improvements in its steam-operated electric power plant at Cahokia, near East St. Louis, to include installation of 75,000-kw. turbo-generator unit and auxiliary equipment, entire project to cost close to $2,000,000. Work is scheduled for completion in 1929.

Ind., Connersville—The Auburn Automobile Co., Auburn, Ind., will install power equipment in new additions to plant at Connersville estimated to cost more than $300,000.

Ind., Shelbyville—The Columbia Canning Co., Cambria, Wis., will install power equipment in proposed vegetable canning factory at Shelbyville, to cost close to $100,000, with machinery. A boiler house is planned.

Ind., Valparaiso—The Fibroc Insulation Co., Valparaiso, L. T. Fredericks, president, will build a one-story power house at new local plant unit for the manufacture of fibre insulating products. Entire project will cost about $100,000. Lockhart & Fett, Associates Building, South Bend, Ind., are architects.

Iowa, Fort Dodge—The Atomized Fuel Corporation, Eleventh Street and Central Avenue, is completing plans and will soon take bids for new local plant to cost approximately $75,000, with equipment. The Pennsylvania Engineering Co., Newcastle, Pa., is engineer.

Kan., Wichita—The Swallow Airplane Co., Wichita, Kan., will install power equipment in connection with proposed plant expansion and improvement program to cost more than $300,000.

Md., Baltimore—The Edward Katzinger Co., 1949 North Cicero Avenue, Chicago, Ill., manufacturer of bakers' machinery and equipment, plans installation of power equipment in proposed two-story plant at Baltimore to cost in excess of $300,000, with machinery.

Mich., Allegan—The City Council has completed plans for a proposed municipal hydroelectric power plant on the Kalamazoo River and is said to be planning early call for bids. Project will cost more than $400,000, with transmission line. Ayres, Lewis, Morris & May, Cornwall Building, Ann Arbor, Mich., are engineers.

Minn., Minneapolis—The Grau-Curtis Co., 613 First Avenue, N. E., plans installation of power equipment in new two-story furniture-manufacturing plant to cost about $100,000. Lang, Raugland & Lewis, Essex Building, are engineers.

Mo., Kansas City—The United Cold Storage Co., 2101 West Pershing Road, Chicago, Ill., has filed plans for proposed five and eight-story cold storage and refrigerating plant unit at Kansas City, reported to cost more than $750,000, with equipment.

N. J., Newark—The Hoffman Beverage Co., 406 Grove Street, plans installation of power equipment in proposed six-story plant addition for storage and distributing service, entire project to cost more than $200,000.

N. J., Nutley—The Hoffman-LaRoche Chemical Co., 19 Cliff Street, New York, plans installation of power equipment in a new four-story plant at Nutley, entire project to cost more than $100,000.

N. Y., Dunkirk—The Dunkirk Radiator Corporation plans installation of power equipment in new local plant unit reported to cost more than $100,000.

N. Y., Lockport—The Harrison Radiator Corporation, Walnut Street, will install power equipment in new one-story addition to automobile radiator plant reported to cost about $135,000.

N. Y., Phelps—The Empire State Pickling Co. will install power equipment in connection with proposed rebuilding of food products factory, destroyed by fire, Nov. 28, with loss reported in excess of $200,000.

N. C., Leaksville—The Marshall Field Mills Corporation will build a one-story addition to boiler plant in connection with an expansion program at local textile mill to cost about $100,000.

Ohio, Rossford—The Edward Ford Plate Glass Co. will install power equipment in proposed new plant unit to cost more than $2,000,000. G. R. Ford is president.

Ohio, South Amherst—The Ohio Cut Stone Co. plans installation of power equipment in connection with proposed rebuilding of portion of plant destroyed by fire, Nov. 27, with loss estimated in excess of $150,000.

Okla., Britton—The Zero Ice & Cold Storage Co., 729 West Grand Street, Oklahoma City, Okla., is perfecting plans for construction of new ice-manufacturing and cold storage plant at Britton to cost close to $30,000, with equipment.

Pa., Bessemer—The Metropolitan Paving Brick Co. plans installation of power equipment in connection with proposed rebuilding of portion of local plant, destroyed by fire, Nov. 28, with loss reported in excess of $250,000. Headquarters are at Canton, Ohio.

Pa., Chester—The Ford Motor Co., Highland Park, Detroit, Mich., plans installation of power equipment in connection with an expansion and improvement program at its Chester assembling and distributing plant, entire project to cost more than $500,000.

S. C. Greenville—The Pearce-Young-Angel Co., Greenville, is having plans completed for a two-story cold storage and refrigerating plant, reported to cost about $45,000, with equipment. Haskel H. Martin, Vickers Building, is architect.

S. D., White River—The Central West Public Service Co., Omaha, Neb., is planning construction of transmission line from White River to Murdo, Presho and Kennebec, with substation facilities for light and power service.

Tenn., Elizabethton—The American Glanzstoff Corporation will install power equipment in proposed new second unit at local rayon mill to cost more than $4,000,000. Plans will soon be drawn. New York office of company is at 180 Madison Avenue.

Texas, El Paso—The Texas Co., Texas Building, Houston, Texas, and 17 Battery Place, New York, has authorized construction of boiler plant at proposed new oil refinery at El Paso, and will install power equipment in main refining unit. Entire project is reported to cost more than $850,000.

Texas, Houston—The American Maracaibo Oil Co., 100 Broadway, New York, will install power equipment in projected refining plant in vicinity of Houston, entire project reported to cost more than $500,000, including pipe line construction.

Texas, Neches—The Humble Oil & Refining Co., Houston, Texas, will install power equipment in proposed gasoline refining plant at Neches reported to cost more than $100,000.

Wash., Seattle—The Isaacson Iron Works, 2917 East Marginal Way, plans installation of power equipment in connection with a plant expansion and improvement program reported to cost close to $100,000.

Replace the old
Steam end with an
ELLIOTT Turbine

1800-hp. Elliott bleeder turbine recently installed in a New England plant to replace the original turbine of the generator set. Two Elliott replacement turbines are operating in this plant.

Add many years

to the life of the old turbine-generator set. A new turbine end will do it.

Many a unit is now operating at a loss because its owners hesitate to scrap a thoroughly serviceable generator. ELLIOTT engineers have met this problem often, and solved it by replacing the outworn, obsolete steam end with a modern ELLIOTT Turbine, set upon the same base plate. The result is an immediate saving in operating cost which quickly writes off the initial cost of the new turbine, and provides a practically new unit at the cost of only one of its elements. This is real economy.

Ask ELLIOTT engineers to figure the matter out for you. Write us the operating facts on your present equipment.

Elliott Power Equipment includes engines and turbines, generators and electrical machinery, condensers, deaerators, heaters, centrifugal blowers and accessory equipment.

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Send Today for a Sample of Rex

Here is a sheet packing which I first started to manufacture in this country back in 1907. I have improved it to a point where I can now give it my unqualified approval.

It is made of asbestos and other heat-resisting materials and does not become brittle or deteriorate with age. Soft and pliable, it is easy to handle.

It is ideal against extreme pressures and temperatures of steam, hot and cold water, ammonia, etc.

A postal card request marked for my attention will bring a generous sample.

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PERFECTED PACKINGS FOR EVERY PURPOSE

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Shaft Friction

Caused by Insufficiently Lubricated Packings Is Sure to Prove Expensive

The packing for the fluid end of the pump should be selected because of its resistance to the fluid it comes in contact with.

FOR WATER PRESSURES
use
"PALCO" packing

especially designed for the exacting service of Centrifugal Pumps, having very high tensile strength and carries such abundance of graphite grease lubricant that the shaft is saved from friction wear.

FOR CAUSTIC SODA and SIMILAR CHEMICALS
use
"CUTNO" packing

It carries in each separate strand a lubricant that resists the washing out tendency of solutions of Caustic Soda and similar chemicals. "Cutno" holds its lubricant for lubricating purposes.

FOR GASOLINE, NAPHTHA, KEROSENE and ALCOHOL
use
"PELRO" packing

Its lubricant withstands the cutting action of all distillates of petroleum, thus keeping the packing soft and pliable and the shaft under constant lubrication, avoiding shaft friction.

Send for free working samples. State size wanted, and service under which packing is to work.

Greene, Tweed & Co.
Sole Manufacturers
109 Duane Street, New York

BELMONT PACKINGS

help in power plant performance with durable service

High Pressure Asbestos Packing No. 20

Thirty-five years of experience have created the Line of Belmont Packings for long, reliable service for every packing requirement.

Resisting high pressures and temperature, this packing comes from the Belmont Plant where it is manufactured from high grade Canadian asbestos and raw rubber, all by our own workmen, which enables us to furnish better packings at less cost per year of service.

No. 20, shown above, holds steam, gas, air at all pressures. Also comes in Spiral Form, No. 30, and Coil Form, No. 40.

Write for our free 93-page illustrated catalogue which tells about these and other packings from the Belmont Plant.

There is a Belmont Packing for every service

High Pressure Asbestos
Superheated Steam
Asbestos Valve Stem
New Departure Hollow Center
Standard Ring
Locomotive
Braided Copper
"6100" for Oils, Gasoline, etc.
Combination Sets in every required form
Flax Packings
Hydraulic Packings
Centrifugal and Rotary Pump
Metallic Packings
Superheated Sheet
Asbestos Metallic Sheet
Gaskets of all kinds
Rubber Pump Valves

Belmont Packing & Rubber Co.

Philadelphia, Pa.

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METALASTIC

For All Stuffing Box Requirements

A DOZEN GOOD REASONS

METALASTIC is the ideal packing for stuffing-boxes.
METALASTIC is not a formed ring packing, hence,
METALASTIC does not require cutting or fitting, since
METALASTIC is furnished in one form for all equipment.
METALASTIC will neither bind nor wear nor score because
METALASTIC is composed of anti-friction materials.
METALASTIC will not harden after prolonged use, therefore
METALASTIC does not require replacement at any time, thus
METALASTIC will eliminate shutdowns for maintenance repair.
METALASTIC is not an experiment under any operating usage for
METALASTIC has served well for more than seven years.
METALASTIC will save your money, your time and your patience.

Let us send you a working sample in proof of these statements.

METALASTIC INCORPORATED
JERSEY CITY, N. J.

No blowouts with EBONITE

Pack joints with EBONITE and you make certain that your pipe lines will be free from packing breakdowns.

EBONITE is a sheet packing tested through years of service. It always gives thorough satisfaction whether on lines carrying high pressures or temperatures, or oils, acids and air.

A trial will convince you

QUAKER CITY RUBBER CO.

Manufacturers of Daniel's P. P. P. Rod Packing
Main offices and factories
Wissinoming, Philadelphia
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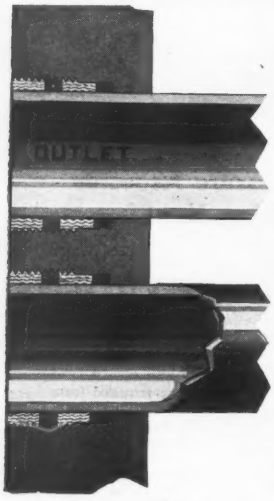
"John Crane"
Metallic Condenser Packing
New Method of Assembly Without Ferrules



Inlet end is packed with fibre bushing containing a lead insert. Tube is expanded as shown. New Condensers, (lower view) may be constructed, rolling tubes into sheets.

Outlet end is packed with endless metallic rings separated by fibre spacers.

Unobstructed flow gives condenser higher efficiency and helps overcome air impact at inflow end.

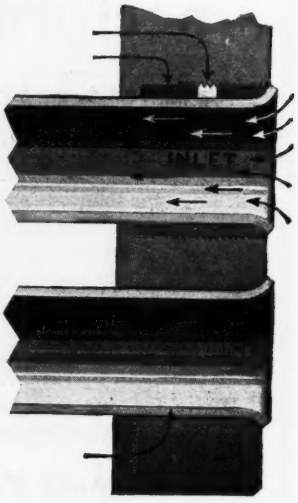
Tubes expand and contract freely through the non-expanding metallic packing, overcoming stresses always present when corset lace and fabric packings are used.

This metallic packing has exceedingly long life and is not affected by impurities in cooling water.

Omission of ferrules saves ten to twenty cents per tube packed.

Many condensers of all sizes are packed with "John Crane" Metallic, including the largest in the world. Used extensively, also, in Naval and Marine Condensers.

Literature on request. Write.



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1802 Cuyler Avenue, Chicago — 21 Bridge Street, New York

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THE LAST WORD IN PACKING

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COMPLETE PACKING INFORMATION

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THE GARLOCK PACKING COMPANY
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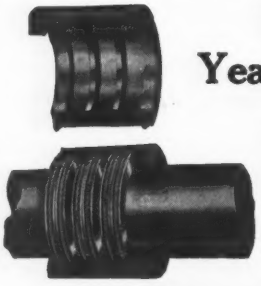
The Standard Packing of the World



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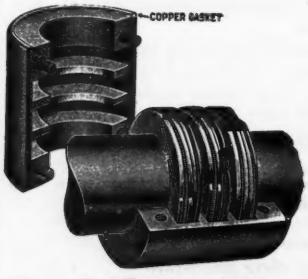
back of Holmes Packings and 23 patents assure you service not obtainable elsewhere. Originators of Split Case.

for Steam, Air and Gas Split Case, etc.

HOLMES METALLIC PACKING CO.
70 Westminster St. Wilkes-Barre, Pa.



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you want a permanent solution for your packing problems we have it. Three months' trial at our expense.

Piston Rod Packings for Steam, Air, Gas and Ammonia

American Metallic Packing Co.
Mexico St., N. S., Pittsburgh, Pa.

We have Allpax installed in practically every large refinery in the United States on centrifugal pumps operating at from 1500 to 3500 r. p. m., handling gasoline and hot distillates at temperatures as high as 500° F. With Allpax, leaking is stopped entirely, and in addition, the possibility of the pump "running hot" is definitely eliminated.

An Allpax representative brings a demonstration stuffing-box right to your plant and SHOWS you just how this remarkable packing is adapted to stuffing-boxes of every size and shape, whether for rotating or reciprocating rods.

At last!

The Perfect Packing for *all* Centrifugal Pumps

—our simple demonstration will prove this positive statement to be a positive fact

ALL power executives and engineers know that a centrifugal pump is only as efficient as its packing. If even the smallest amount of air is sucked through the packing of a centrifugal pump, capacity is cut down very materially. Any excess of air breaks the suction, thereby shutting the pump down completely, frequently with disastrous results.

But it takes a fine packing to stand the gaff.

Allpax, the recognized universal packing, is just such a packing. You will find it in hundreds of plants where centrifugal pumps undergo the hardest kind of service. The executives of these plants find that Allpax prevents air-sucking and leakage, eliminates scoring and makes replacement of shaft sleeves or worn-out packing a thing of the past. When Allpax wears, all you need to do is to back off the glands and add a little more.

There is no waste with Allpax.

We don't ask you to believe a word we say about Allpax —it sells on demonstration—the most convincing demonstration of packing ever made. The convenient coupon below secures this demonstration right in your own plant.

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THE PACKING THAT "PACKS ALL"

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Jobbers in every important city

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We use centrifugal pumps for.....

Send us your representative with the Allpax demonstration

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MODERN power plant practice calls for Leakless Joints and Tight-Seating Valves!

METALLO Valve Discs Round Hole type, made in ¼", ⅜", ½" and all sizes above 2". Also Square Hole type.

"Insist on Metallo"

Steam, gas, chemicals and other media that pass along pipe lines and are controlled by valves, are weighed, checked, recorded and their value safeguarded at every turn in the modern power plant.

Likewise in such plants a leak is as quickly attended to as a hot bearing or a popping safety valve.

Naturally there must be no leaks and the scientific selection of the means of prevention leads to standardization on Metallo Gaskets and Valve Discs.

Why leading plants and foremost engineers order and reorder "Metallo" is shown in the Metallo Catalogue 26. There is a Metallo gasket for every service and a valve disc that outlasts many ordinary discs for any Jenkins Type Valve.

Note to send for this free book containing also valuable information on metals for different industrial services and other engineering data. From it select the gaskets and discs you wish to try free for 90 days.

METALLO GASKET CO.
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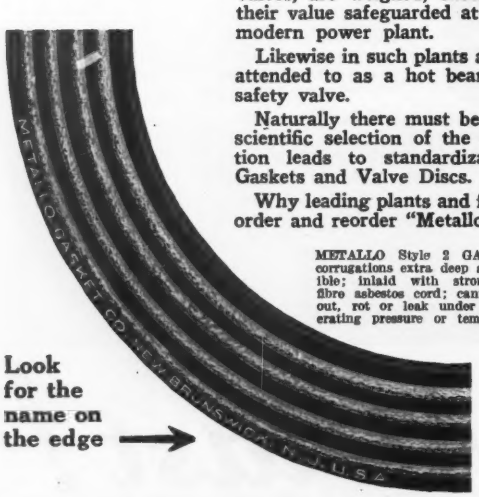

METALLO Style 2 GASKETS; corrugations extra deep and flexible; inlaid with strong, long fibre asbestos cord; cannot blow out, rot or leak under any operating pressure or temperature.

Look for the name on the edge →

METALLO GASKETS *and* VALVE DISCS

FLEXCO-LOK
Lamp Guards
Stop Lamp Losses

STOP dangerous breakage and annoying removal of lamps. Save eye strain with suitable reflectors... These tin-finished, steel guards are made in sizes to protect all lamps up to 200 watt. Both reflector and plain styles . . . Flexco-Lok close with key and Flexco with screwdriver... Note especially the portable guard (not sampled). Split handles permit easy adjustment. Safe and convenient for extension lights.

Sample on Request

Sample 60-watt guard on letterhead request. Give socket diameter. Stocked by supply houses.

FLEXIBLE STEEL LACING CO.
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FLEXCO
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"Flexitallic"
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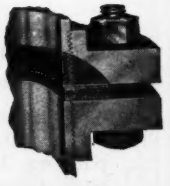
a flexible metallic gasket built on correct mechanical principles to withstand modern high pressures and temperatures. For Boilers and Pipe Lines.



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Use
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An adjustable metal seal which does not wear or score the rod.

Gives years of service on rods of steam pumps or engines. Also particularly adapted for all kinds of rotary pumps. Five and ten-pound cans.

Forms with the fingers in any size.

The Conneaut Packing Company,
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Please send sample and information on your packing.

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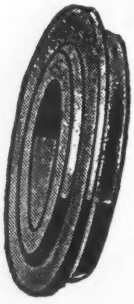
The simplest of devices!



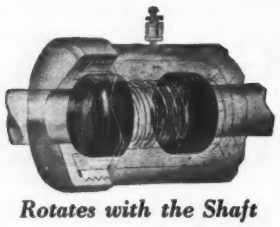
and yet it ends all stuffing box troubles

ALL year 'round Cooke Seal Rings prevent leaks on rotary shafts. They're making records that are astounding; even those engineers who were at first doubtful are now won over to this mechanical device that reduces friction 90 per cent and maintains a leakless pressure or vacuum on industrial gases, fluids and air.

Orders and reorders from all parts of the world for Cooke Seal Rings prove that the correctness of design and engineering principles employed in this Ring give perfect performance. Renewals and attention are practically unknown except for oiling three or four times a year.

Some of these rings have been in constant-duty service for over six years.

Investigate this money saver. Write for booklet and detailed explanation of Cooke Seal Ring Assemblies for practically all services.



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Established sales organizations already familiar with industries in their territories are invited to get in touch with us. We are now selecting distributors for Cooke Seal Rings throughout the United States and abroad. Inquiries from our advertising in trade journals have resulted in the sale of nearly 200,000 Rings during the past two years. Our increased business has brought about this need of responsible agents. Write.

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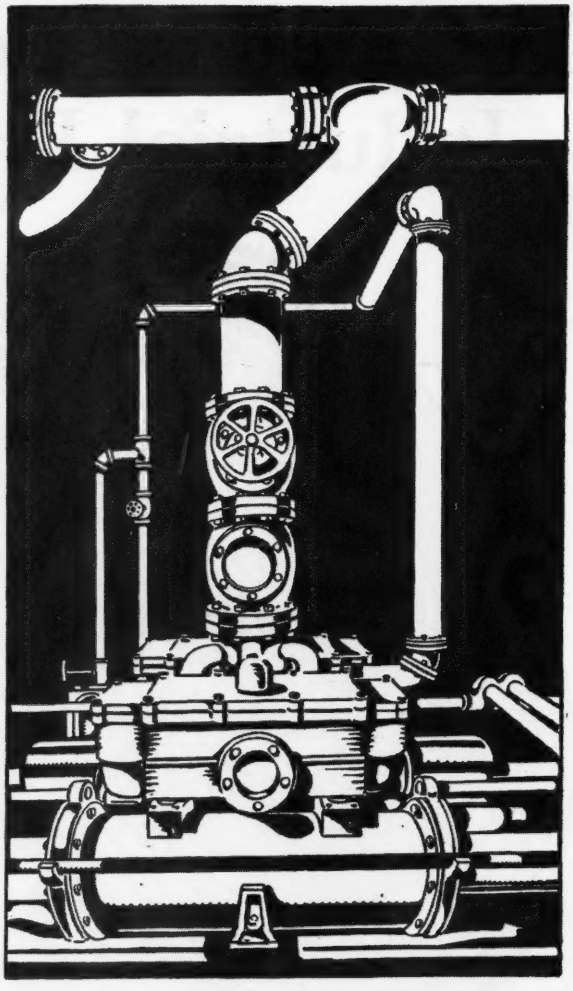

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THE properties of asbestos which give it its great resistance to heat are equally valuable not only in rendering

VULCABESTON PUMP VALVES

impervious to oils, acids, brine and other erosive chemicals, but in giving them the most extraordinary strength for withstanding pressure and toughness for resisting the wear of friction.

Remember the name

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the buyword of those who know the economy of quality.

COLT'S PATENT FIRE ARMS MFG. CO.

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Dearborn
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SCIENTIFIC LUBRICATION

for UNIFLOW ENGINES

This is another service in which it has been difficult for many engineers to find the right oil.

And it is another service where a Dearborn Oil is giving unsurpassed service.

Flash and Fire Test—Cleveland open cup (oil). Method 110.3. A. S. T. M. Method D 92-21T.

Dearborn Ft. Wayne X Machine Oil has given nine months without change on an Ames Vertical Uniflow Engine. It can be relied upon for three or four months' service on Uniflow Engines of any type.

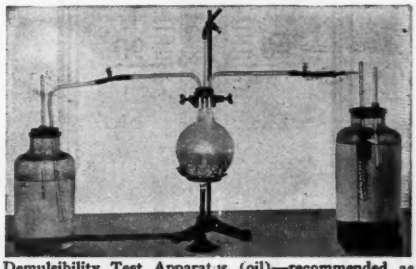
Standard Saybolt Universal Viscosimeter (Standard in the United States for determining Viscosity)—Method 30.11—A. S. T. M. Method D 47-22 T.

The special features of this oil are:

It will not emulsify. Many other oils do emulsify, turning into a dark brown sludge of no lubricating value. This not only makes the oil bill unreasonably high, but develops very high friction temperatures.

Viscosity exactly suitable.

High flash and fire test. Unaffected by any temperature encountered in Uniflow Engine service.

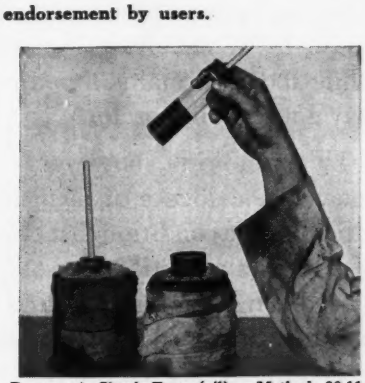


Demulsibility Test Apparatus (oil)—recommended as tentative method by A. S. T. M. Method 320.3 A. S. T. M.

Pure Pennsylvania stock.

Cost only two-thirds as much as some of the oils sold for this service.

Staunch endorsement by users.



Pour and Cloud Test (oil). Method 20.11. A. S. T. M. Method D 97-22 T.

Try Dearborn Ft. Wayne X with our assurance that it has replaced other oils and stopped lubrication trouble in many plants and can be depended upon to do the same for you. Discuss this with your Dearborn service man or write us.

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299 Broadway
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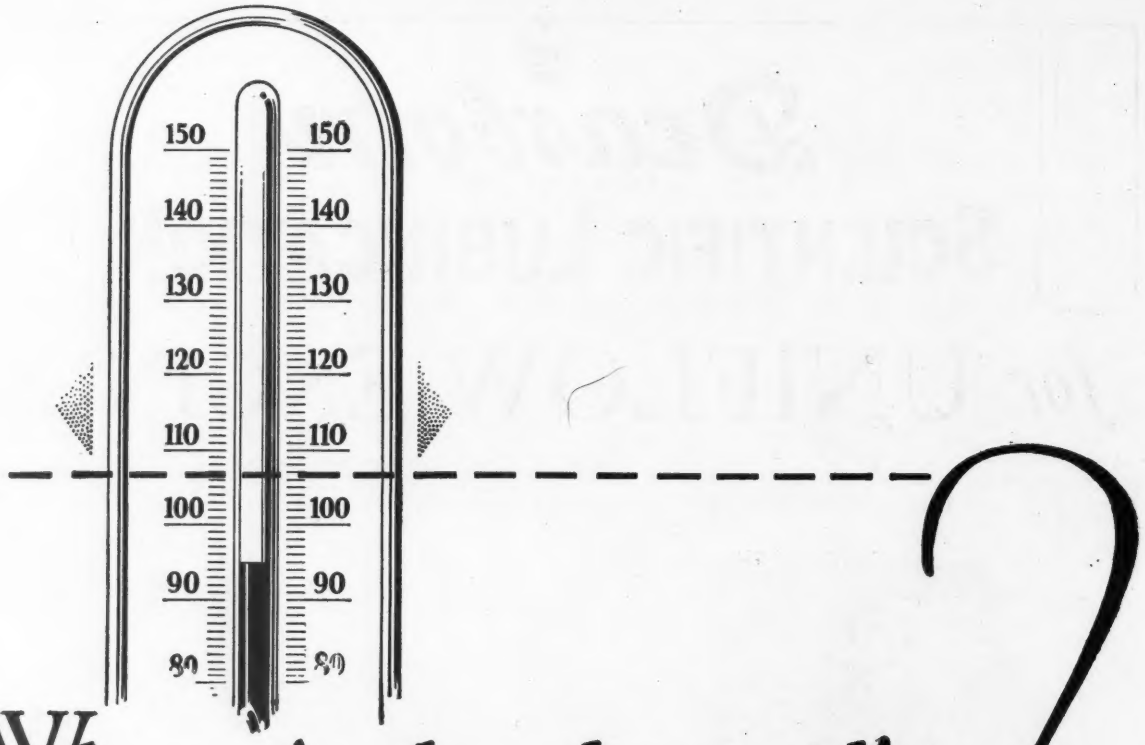
Ft. Wayne X Machine Oil



Where is the danger line?

It is not uncommon to find turbine or other bearings in power plants running unusually warm. As this temperature, while above normal will not increase, it may not seem important.

This condition, however, is usually conclusive evidence of inefficient lubrication. It is a condition that causes waste of power; a condition that takes its toll by reducing bearing life. It is a condition that Standard Oil Company (Indiana) Lubricating Engineers have remedied in many plants. Hot bearings have been unknown at the Highland, Illinois, Municipal Light and Power Company since they began using Standard Lubricants two years ago. They say:

"Your oils have now been used exclusively in our poppet valve uniflow engine for two years and in our Westinghouse 750 K. V. A. Turbine for the past year. During this time we have received perfect lubrication."

Perhaps you are not quite satisfied that you are getting perfect lubrication. Our lubrication engineers will be glad to make a survey of your plant and offer lubrication recommendations—without charge. Just get in touch with our nearest branch office.

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CURTIS TYPE T RETURN TRAP

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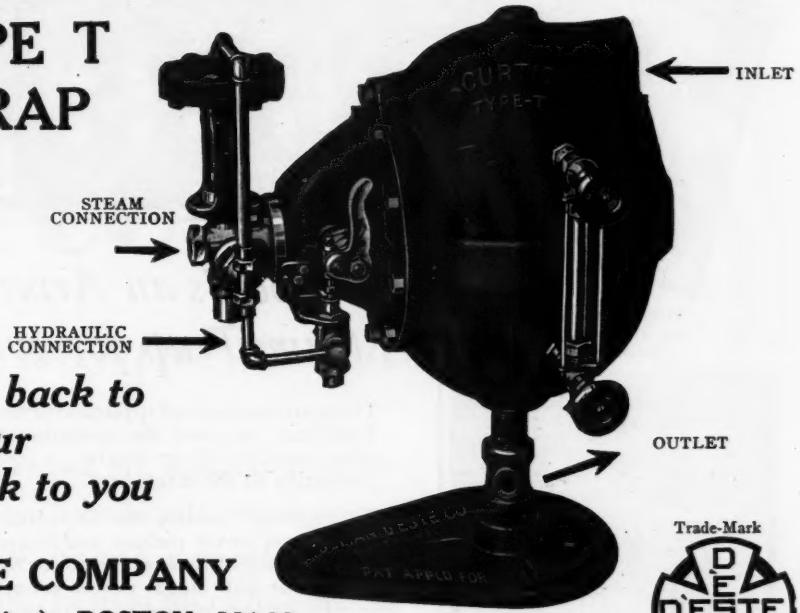

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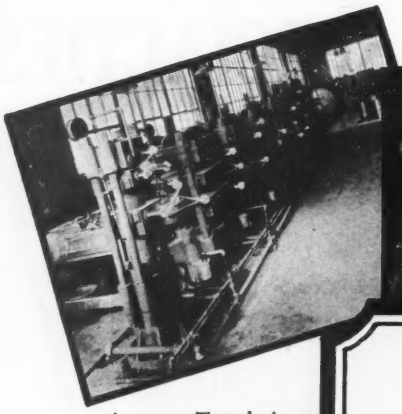
Dixon's Flake Graphite

Recognized the world over as the standard lubricating graphite. Used alone, or as an auxiliary lubricant with oils and greases, Dixon's Flake Graphite materially increases the operating efficiency of every machine it is used on.

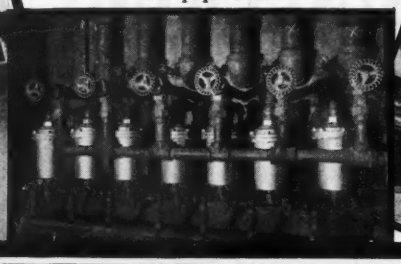
Even tho Dixon's Flake Graphite has been used by thousands of mechanics, maintenance men and engineers for more than 100 years —do you know the . . . how . . . and . . . why . . . of Dixon's Flake Graphite lubrication?

Joseph Dixon Crucible Co.
Jersey City, N. J.



Armstrong Trap draining vulcanizing presses in rubber factory.

A group of Armstrongs on indirect fan dryer on wall paper mill.



Armstrong Trap on steam engine header.

There's an Armstrong Steam Trap for every need

There are hundreds of applications where Armstrong Traps can improve the operation of steam units, effect considerable savings in the coal pile and give protection to the machinery.

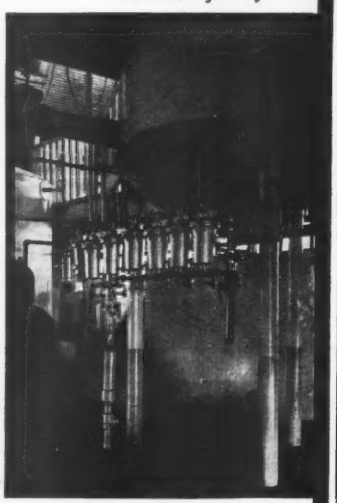
All engineers realize the importance of draining water from steam turbine and engine headers, and a great many of them prefer to let Armstrong Traps do it. Not only steam power units, but machinery in which steam is used for heating purposes should be equipped with Armstrong Traps to insure complete removal of condensate without the loss of live steam. The investment is small and profitable.

Armstrong Traps are simple and dependable. They are always water sealed against the escape of live steam and are self scrubbing. They discharge air, oil and dirt with the condensate. Heat treated chrome steel valves and seats are used to prevent leakage and prolong the life of the traps. The small size of Armstrong Traps makes installation an easy matter and a neat looking job.

We will gladly let you test an Armstrong Trap without cost or obligation. All you have to do is fill in and send the coupon.

ARMSTRONG MACHINE WORKS
310 Maple Street, Three Rivers, Mich.

District Representatives in 36 Cities



Armstrong Steam Traps on vacuum pans at a creamery.

Steam separator on main steam turbine line drained with an Armstrong Trap.

Mangles and other laundry machinery are effectively drained with Armstrongs.

ARMSTRONG MACHINE WORKS,
310 Maple St., Three Rivers, Mich.

Please ship prepaid an Armstrong Trap for a 90-day test. When the test is completed the trap will be returned collect.

For service on _____

Size of pipe _____ *Steam Pressure (Maximum)* _____

Name and position _____

Firm _____

Street Address _____

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employs unique method

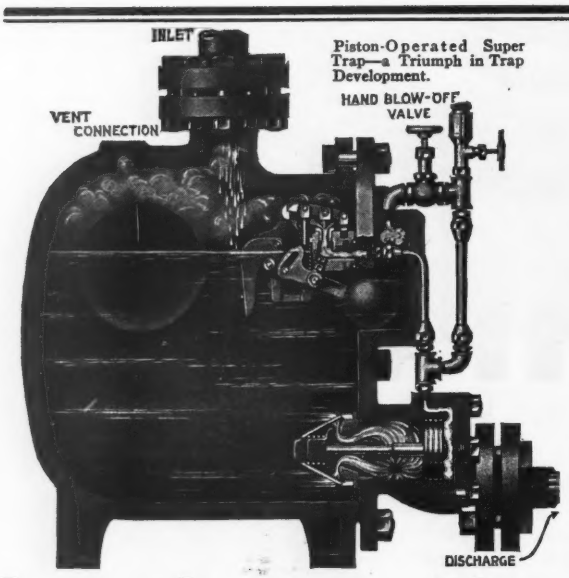
Since compressed air was required for other operations in the Nujol Company plant at Bayway, N. J., the management reasoned that it could also be used for drying bottles if condensate was thoroughly removed.

Tests with Swartwout Air Separators and Swartwout Traps in the air line showed this unique method workable. Clean, dry air made rapid, economical bottle drying possible. Needless to say, Swartwout equipment was purchased and installed.

There's a Swartwout Separator for every removal job . . . a Swartwout Trap for each drainage requirement.

THE SWARTWOUT COMPANY
18541 Euclid Avenue , Cleveland, Ohio

Swartwout
Power Plant Equipment



Piston-Operated Super Trap—a Triumph in Trap Development.

In modern practice NICHOLSON TRAPS stand supreme

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—and many others.

Steam traps are most important factors in power plant economy and here's the Super Trap that makes steam trap troubles a thing of the past. You can trust the safety of your most valuable machinery and equipment to its certain action and great capacity that will handle any slugs of water that may come through.

Meets all modern high pressure and superheat conditions and costs less per year of service because of its endurance. Low first cost considering its capacity. The Master Trap for Superheat and High Pressures.

Steam Traps are our specialty and we invite you to call on us for assistance on any Trapping problem.

The Piston-Operated Super Trap for extreme conditions is used for all services from 0 to 1350 lbs. The Weight-Operated Trap for 200-lb. and 450-lb. will not wire draw. The Expansion Trap is industry's favorite for all kinds of process apparatus—Heating Coils, Paper Machine Rolls, Steam Separators, etc.

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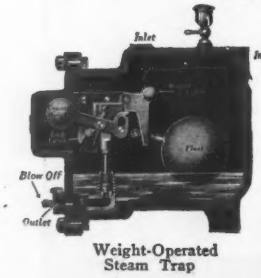
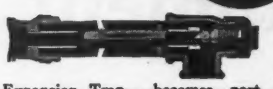
120 Oregon St., Wilkes-Barre, Pa.



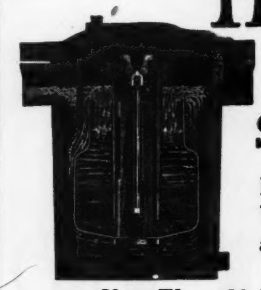
Weight-Operated Steam Trap

Nicholson Patented Welded Steel Float Exlusively used on Nicholson Traps.



Expansion Trap— becomes part of the Heating Unit to which it is applied.

ILLINOIS Eclipse STEAM TRAP



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Note These 10 Superior Features:

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3 SIMPLE—ONLY 2 MOVING PARTS—no pins or levers.
4 CAN'T AIR-BIND—automatically vents.
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9 MONEL METAL VALVES AND SEATS.
10 REMOVABLE TOP—inspection easy without disturbing piping.

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ROBT. L. GIFFORD, PRES. INCORPORATED 1900
BRANCHES AND REPRESENTATIVES IN 40 CITIES
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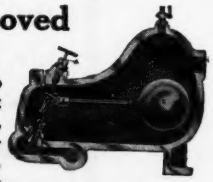
McDANIEL Improved Steam Trap



Requires no adjusting. Easy to repair. Guaranteed to give best results on Heating Systems, Heating Coils, Cooking Utensils, Hot Water Generators, Drying Boxes, Ironing Machines, Separators, etc. In fact, wherever water of condensation is to be discharged. Owing to the large discharge capacity of McDaniel Traps, one to two sizes smaller can be used than most Traps on the market.

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New Improvements Write for Information

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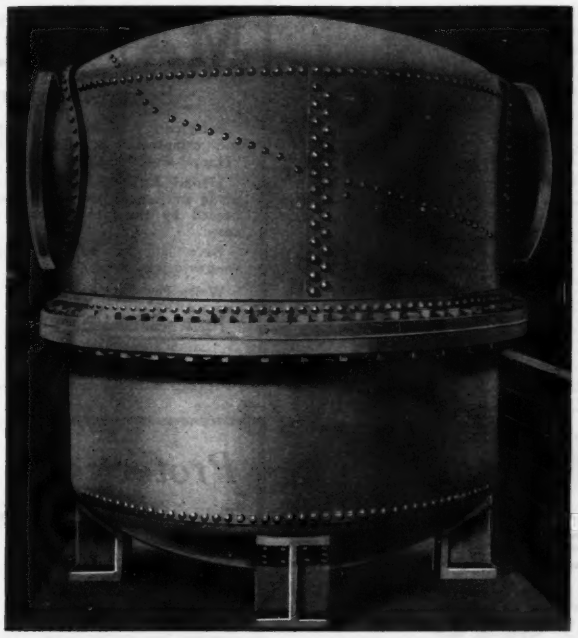
39 Elm St., Nashua, N. H.

Clean Dry Steam Saves Fuel



Install Sweet's DIRECT Separators Now!

Sweet's Combination Oil Separator capacity 48,000 lb. steam per hour. Under 26-in. vacuum. 30-in. Connection.

AT MANY leading plants that are pointed to as examples of engineering ability, Sweet's Direct Separators are serving. For more than 30 years now these separators have been separating water from steam, oil and water from exhaust steam, and oil and water from compressed air.

Guaranteed to deliver steam 99.5 per cent dry, Sweet's Separators effect great savings in repairs, oil and fuel. Dependable and economical anywhere. Write for catalogue describing the Combination Oil Separator shown above and the entire line of Sweet's Direct Separators. Special Separators made to meet all special requirements.

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Cast-In-One-Piece Separators Show Superior Workmanship

Wright-Austin Cast-in-one-piece Steam Separators are built with exceptional skill by men who have been more than 20 years at this work.

Type "M" Steam Separator

The Type "M" Wright-Austin Steam Separator shares in the general excellence of workmanship and material which characterizes the entire line.

WRIGHT-AUSTIN CO.
321 W. Woodbridge St.
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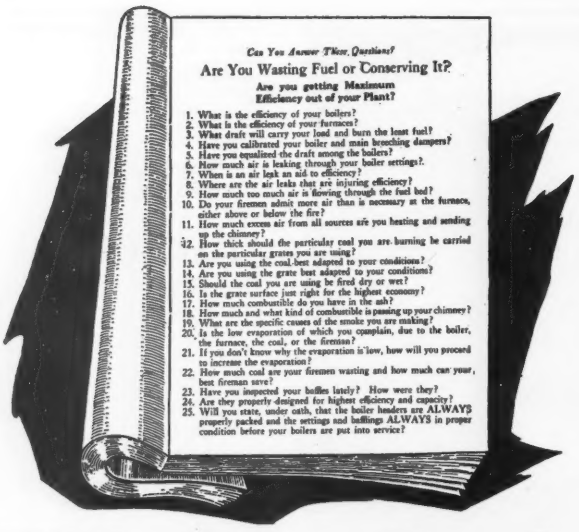
WRIGHT WA Standard since '94 AUSTIN


Can You Answer These Questions?
Are You Wasting Fuel or Conserving It?
Are you getting Maximum Efficiency out of your Plant?
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5. Have you equalized the draft among the boilers?
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Would you like to have the opportunity of getting a thorough knowledge of Combustion and Boiler Room Management in your spare time and at a very small cost, payable monthly if so desired? Jos. W. Hays, author of the Course and Educational Director, formerly Consulting Combustion Engineer of the U. S. Navy, together with a group of leading combustion experts, has now made it possible for you, through the Hays Course in Fuel and Combustion Engineering and Boiler Room Management, to obtain a thorough knowledge of Combustion in your spare time without interfering with your present work in the least.

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Safeguard your engine, pump and compressor cylinders with "Manzel Positive Lubrication."

Manzel Lubricators are automatic and supply the oil just as needed by the machine at any speed.

Save 30 to 60% of oil wherever installed.

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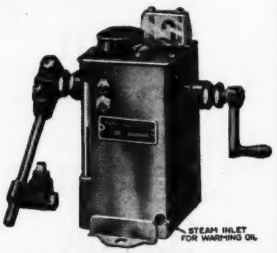

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for roofs and walls with Hoppes Exhaust Heads

Longer life for buildings, no damage suits and saving of heat units in the exhaust condensate are insured by installing these heads. Write for full information on Hoppes intercepting troughs used on our Exhaust Heads, Steam Separators and Oil Eliminators. Catalogue 90 gives full information.

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Combustion Control
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Boiler Water Conditioning
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Irrespective of the Percentage of Moisture Now in Your Steam

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The Steam Purifier

—the glories of the nineties are the jokes of today . . .

But the differences between the old order of things and the new are essentially matters of mechanical detail. Read how a little money invested in modernizing the heating system changed the whole complexion of things for a fine New York hotel.

* * *

MODERNIZATION of the heating system in the Endicott Hotel, New York, was an investment in economy—*saving fuel costs . . . saving costs of redecorating ceilings and walls damaged by leaking radiators . . . saving cost of air valves, which required frequent replacements.

An eight-story, U-shaped corner structure, the Endicott was always difficult to heat. When first installed, the two-pipe gravity system was considered satisfactory, but with the development of the art of heating, the system was rapidly becoming obsolete and proving a handicap.

Three boilers were required to maintain any degree of comfort in outside rooms during cold weather . . . Even with a pressure of from five to seven lbs. the farthest rooms were not well heated. Complaints of insufficient heat and demands for more pressure made careful firing impossible, increasing the difficulty and waste in operating the boiler plant. Radiators were a source of constant annoyance to guests and expense to the house, due to noise and leakage.

In 1923, after an investigation by the Chief Engineer, the two-pipe gravity system was supplanted by a Webster Vacuum System of Steam Heating.

Now—the cold weather load is easily carried on one large boiler instead of three . . . Steam is generated at ten lbs. and reduced to about one lb. for distribution through the mains. Water does not accumulate in the radiators and does not leak out of the system.

Each guest is now able to regulate the heat in his own room . . . Complaints of insufficient heat are eliminated—for the same temperature is easily maintained in all 480 rooms. The modernization was an investment in economy and a builder of good will . . . a hotel's greatest asset.

The many sources of waste through continuing in operation obsolete and faulty heating systems is truly amazing. Let us give you the facts.

- since 1888

Webster
Systems of Steam Heating

Warren Webster & Company
Camden, New Jersey
Pioneers of the Vacuum System of Steam Heating
52 U. S. Branch Offices
In Canada, Darling Bros., Ltd., Montreal

*This is number three of a series on Modernization of Heating Plants. The savings referred to are facts brought out by a survey made by a firm of Consulting Engineers. On request we will gladly submit copies of this and other surveys of similar character for your examination.

Warren Webster & Co., *Camden, New Jersey*

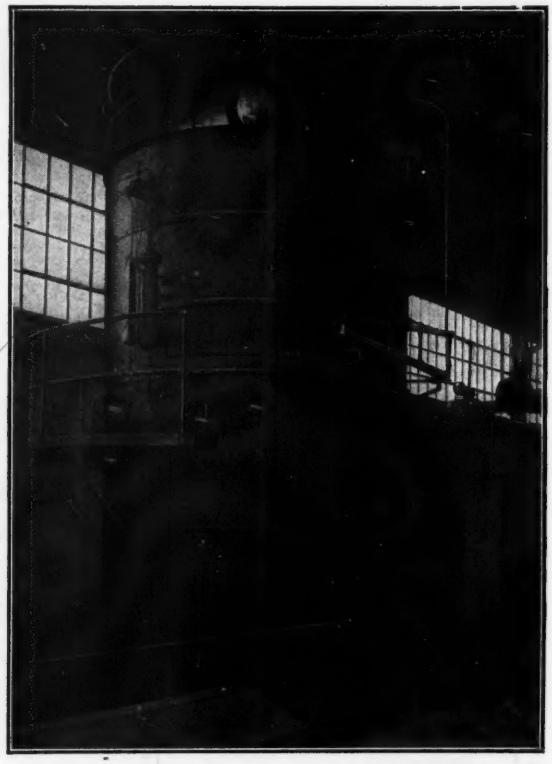
We would like to read about the money saved by "Modernization of Obsolete Heating Plants."

NAME_____ TITLE_____

ADDRESS_____

PPS-12-28

What is the Cost of Modern Regulation?



COPES can give you a *modern* system of boiler feed control, designed exactly for the conditions in your plant, at an investment but slightly higher than that required for ordinary regulation. And, when you consider costs over a period of years, you'll find *modern* COPES Regulation more economical. Thousands of COPES users testify to that.

World wide resources of engineering skill and manufacturing facilities make this possible. A staff of highly-trained engineers devotes all its time to problems of feed water regulation. Seven COPES factories in America and Europe work constantly to keep manufacturing costs on a low level.

You benefit from these resources when you install the COPES System of Boiler Feed Control in your plant. The COPES System effects economies in your plant which pay for the equipment in short order. So that *modern* regulation really costs you nothing. You simply make an investment which is repaid to you many times over during the life of the equipment.

Literature on the COPES System on request.

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1222 Grove Drive, Erie, Pa.
Branch Plants in Canada, England, France, Germany, Italy and Austria. Representatives Everywhere.

COPES
SYSTEM OF BOILER FEED CONTROL

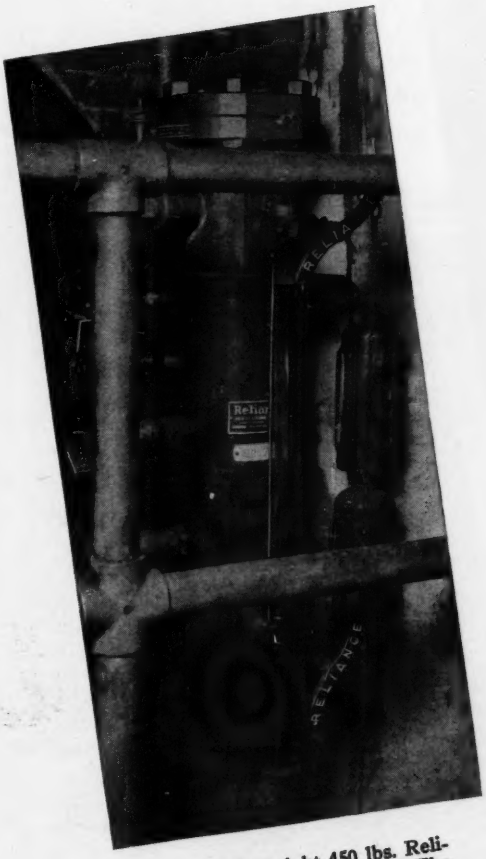
A sow's ear won't make a silk purse

NEITHER can an automobile gain such a world-wide reputation as the Packard has done without an organization behind it that knows wheat from chaff when it comes to the selection of man power equipment and materials.

So, in choosing Reliance Columns, to guard boiler water levels in its new power plant, The Packard Motor Company substantiates what is already an accepted fact throughout the power plant field—that water columns are essential to power plant safety—that Reliance are the most dependable columns made.

And—you can't go wrong in selecting Reliance for your boilers because a company with as enviable reputation to maintain as The Packard Motor Company has would not even choose a cap screw haphazardly or install equipment that wasn't an absolute efficiency essential.

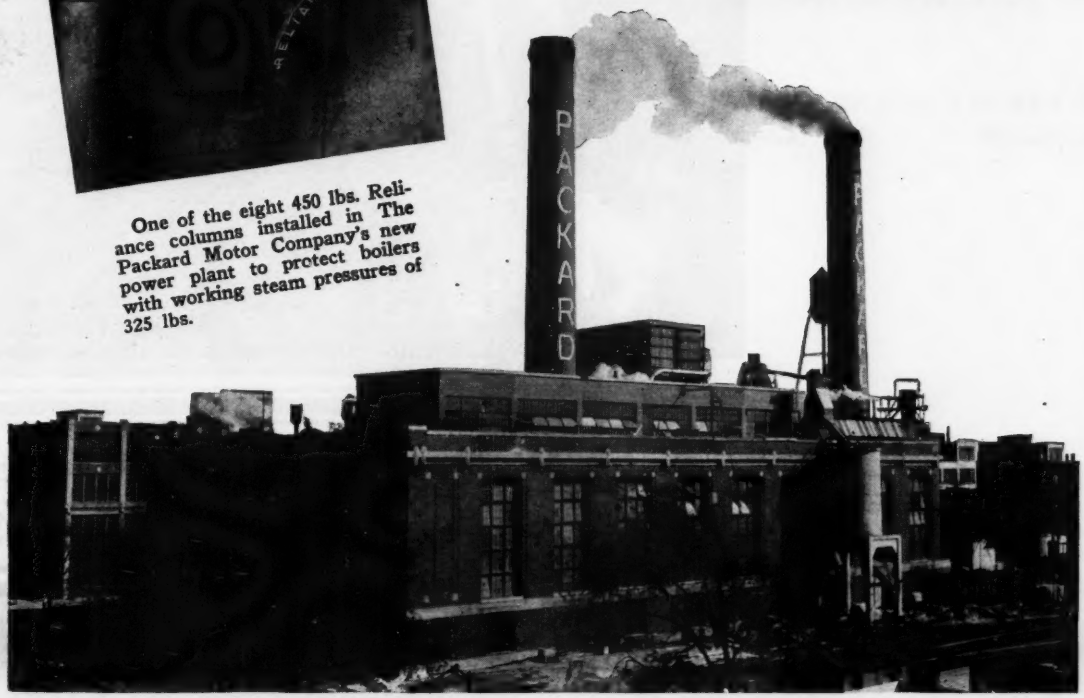
Remember, even the best of boilermen have off-colored days—times when slip-ups come easy. Don't risk a damaged boiler—a prime-wrecked engine or an explosion when this dependable safety costs so little. Tell us your pressures today.



One of the eight 450 lbs. Reliance columns installed in The Packard Motor Company's new power plant to protect boilers with working steam pressures of 325 lbs.

THE RELIANCE GAUGE COLUMN CO.
5932 Carnegie Ave., Cleveland, Ohio

Reliance



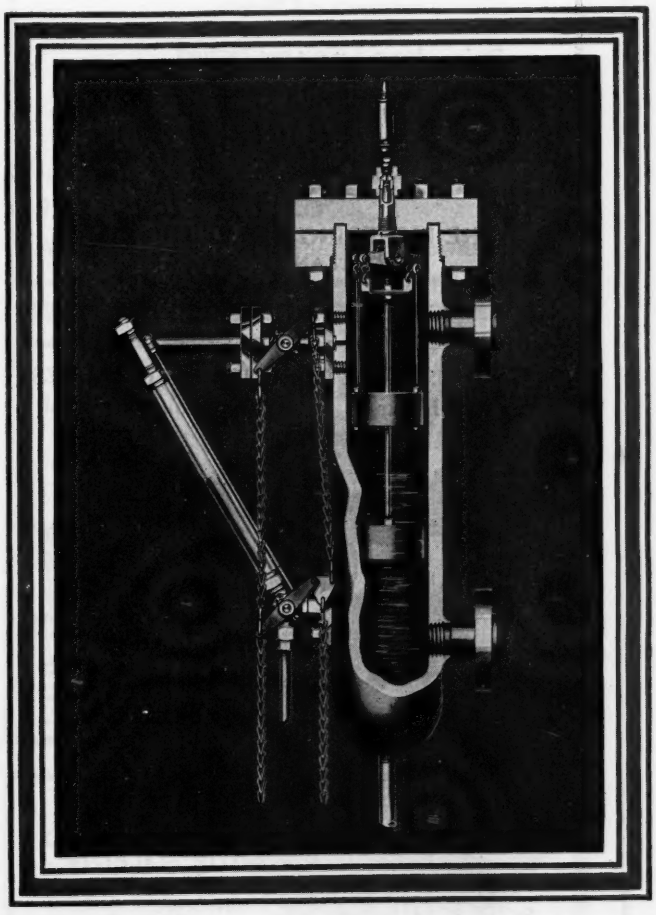
Read

YARWAY SE-SURE INCLINED WATER GAGE, Type E. Flanged connections for working pressures up to 400 lbs. Special Gages for higher pressures.

YARWAY

the Water Level at a Glance!

IT is easily done, however high up on the boiler it may be, if the water gage is a Yarway Se-Sure Inclined Water Gage Inclining the gage glass at an angle of 60 degrees permits instantaneous reading of the boiler water level from anywhere on the fire-room floor—even from directly beneath.



Cross-section of YARWAY FLOATLESS HI-LO ALARM WATER COLUMN with YARWAY SE-SURE INCLINED WATER GAGE. Water Columns are made in both forged steel and gray iron; Water Gages of hydraulic bronze with any type of tubular, prismatic or flat glass for all pressures up to 600 lbs. Special Columns and Gages for higher pressures.

Yarway Se-Sure Inclined Water Gages are made in four types for all pressures up to 600 lbs. They are sold separately, or in conjunction with the Yarway Floatless Hi-Lo Alarm Water Column—the water column that operates on the displacement principle, entirely without floats.

Both Yarway Water Columns and Water Gages are illustrated and described in all sizes and types for all working steam pressures in Bulletin WC 1801. Send for your copy now.

YARNALL-WARING COMPANY
Mermaid Street Philadelphia

BOILER DEVICES

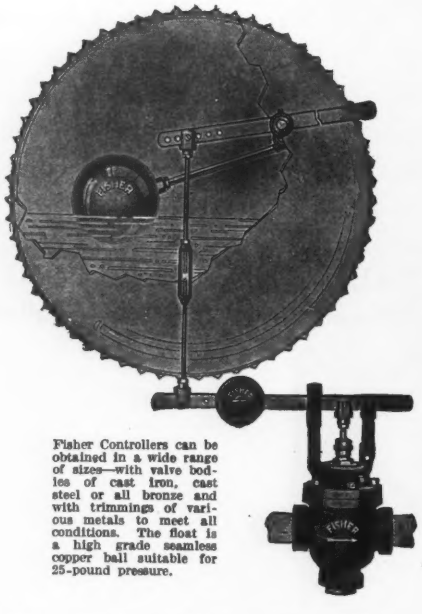
FISHER

Float Valves and Tank Controllers

Have you a liquid control job? Whether it is in an open or closed tank—or for hot or cold liquids, steam, oil, gas, etc.—there is in the wide FISHER line a type of controller to suit every requirement. And—not only that—but FISHER products are built to fit your specific need—they are not "garden variety" stock. A casual inspection will show up points of superior design, workmanship and material. They are economical to buy and decidedly low in upkeep cost.

The type 27 (illustrated) is one of the many methods of installation and as such can be used for controlling steam pumps pumping into or out of tanks. Movement of float operates valve and throttles steam to pump according to the liquid level. Also adapted for controlling flow to tank by placing lever valve in pipe line.

These popular devices are fully illustrated in Bulletin 25—write for a copy.



Fisher Controllers can be obtained in a wide range of sizes—with valve bodies of cast iron, cast steel or all bronze and with trimmings of various metals to meet all conditions. The float is a high grade seamless copper ball suitable for 25-pound pressure.

The Fisher Governor Co.
1200 Fisher Bldg., Marshalltown, Iowa

Fisher builds for steam, air, water, gas, oil, etc., use—pump governors, pressure regulators, reducing valves, liquid level controls, float valves, strainers, steam, air, grease traps, back pressure valves, pressure relief valves, lever valves, vacuum regulators, etc.

PICKERING

Standard for nearly 70 years

Quick responsiveness to load changes—close and accurate regulation—unfailing dependability under severe and continuous service—have made Pickering Governors known the world over as the "Standard of Governing Control."

Pickering Governors are designed for every type of power and speed control purposes—and are almost universally used on

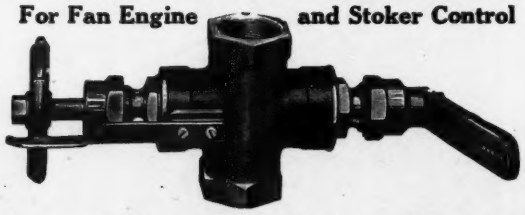
Paper Machine Drives
Electric Generating Sets
Mechanical Stokers
Exhausters and Blowers
Refrigerating Units
Steam Engines and Turbines

Our engineers are at your service. Write them without obligation. Booklet 58M, sent free, describes in detail Pickering Governors and the many services for which they are adapted.

"Governor Builders Since 1862"

THE PICKERING GOVERNOR CO.
PORTLAND, CONN.

R-K ADJUSTABLE CHRONOMETER VALVES
For Fan Engine and Stoker Control



One of these valves controlled by an R-K *Step Action* Hydraulic Fan Engine Regulator gives most desirable Fan or Stoker Engine control.

R-K RUGGLES-KLINGEMANN MFG CO.
Manufacturers Complete Line Draft Control Equipment
MAIN OFFICE and WORKS R-K Building, Salem, Mass

EVERBRITE

Casting Metal

The Nickel Copper Alloy with unequalled casting properties, possessing exceptional strength and resistance to corrosion and erosion of steam at high pressures.

Send for Descriptive Booklet

AMERICAN MOND NICKEL COMPANY
CENTURY BUILDING · PITTSBURGH, PA.

The CAMPBELL
Boiler Feed Water Regulator

is meeting world-wide favor owing to its certainty in handling any boiler condition—slow feed, fast feed, irregular feed, flash type boiler, or any other kind.

No floats This is a long step in the right direction. Floats give everlasting trouble. The actuating force of a float is limited to its volume of displacement. The CAMPBELL has no strength limit.

No thermostats

Nothing delicate about the CAMPBELL. No matter what the boiler room temperature, the CAMPBELL remains unaffected. Can't get air bound. No adjusting.

No generators

Very rugged and reliable. The two tiny orifices shown in the view at the right do the trick. Can't get out of order.

No moving parts

Any man who can cut and fit pipe can install the Campbell. Satisfaction positively guaranteed.
Write for detailed information.

Regulating Valves for Every Service

- ☐ Feed Water Regulators
- ☐ Reducing Valves
- ☐ Damper Regulators
- ☐ Temperature Regulators
- ☐ Pump Governors
- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves

Atlas Valve Co., 291 South St., Newark, N. J.

ADEQUATE INSURANCE

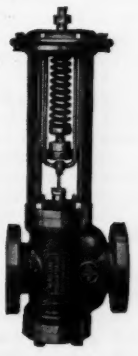
YOUR boilers equipped with Penberthy Automatic Injectors are absolutely safe from the danger of temporary failures in water supply. The Penberthy Automatic Injector is always ready for instant action. It requires no attention and there is practically no maintenance cost—in short, it is the cheapest boiler feed insurance you can use.

PENBERTHY INJECTOR COMPANY
ESTABLISHED IN 1886 — DETROIT — CANADIAN PLANT WINDSOR, ONT.

"We'll put a Mason Regulator in that line, Bill—

and hold the pressure where it's supposed to be. There are enough things to do around this plant without having to worry about accurate pressure control. I'll look up the right one in their catalog and order it today."

Every Mason Regulator is designed, built and tested to meet the most exacting conditions of service. You can depend upon them for accurate, trouble-free pressure control. Write for a copy of newly revised Catalog No. 62.



Mason Pump Discharge Pressure Regulator

Mason Regulators

MASON REGULATOR CO.
Boston, Mass.

San Francisco Office, 606 Howard Street

2168

OTIS
ELEVATORS

The Standard of the World for Three Quarters of a Century

OTIS-SERVICE
INSPECTION and MAINTENANCE

There are 178 Otis offices throughout the United States where skilled mechanics and stocks of repair parts are available, giving owners the class of service to which they are entitled by their purchase of this high grade elevator equipment.

OVER 25,000 ELEVATORS IN ALL PARTS OF THE COUNTRY ARE UNDER SOME FORM OF OTIS-SERVICE

Ask Our Nearest Office

OTIS ELEVATOR COMPANY
OFFICES IN ALL PRINCIPAL CITIES
OF THE WORLD

Constant Excess Pressure on the Feed Line Is Best

Piston Type

It is absolutely necessary for highest possible operating efficiency and economy. Have you had any difficulty in maintaining a FIXED excess pressure on your feed lines? This trouble can be completely overcome by equipping your feed pumps with

FULTON Boiler Feed Pump GOVERNORS

They automatically maintain a CONSTANT difference between the pressure in the feed pipe and the pressure in the boilers. No matter how the steam pressure varies, this excess will always remain constant. The speed of the pump is automatically regulated according to the requirements of the boiler. When little water is needed, the governor cuts down the pump speed by throttling its steam supply, and vice versa.

Absolutely reliable in operation. Made in two types—piston and diagram.

Ask for Bulletins

The Chaplin-Fulton Mfg. Co.

28-40 Penn Avenue, Pittsburgh, Penna.

Also Manufacturers of the Vigilant Feed Water Regulator

APEXIOR REG U.S. PAT. OFF.

—an accepted protective coating for hot water and steam surfaces of boiler plant equipment

Write for Bulletin

THE DAMPNEY COMPANY OF AMERICA

Hyde Park, Boston, Mass.

The preferred babbitt

The choice of thousands of engineers because always uniform in composition, melts and pours well, and assures cool running, efficient and economical bearings.

Obtainable from your local dealer. Send for free booklet.

MAGNOLIA METAL CO., 75 WEST ST., NEW YORK

MAGNOLIA ANTI-FRICTION METAL

REG. U.S. PAT. OFF.

In the metal line, specify Magnolia Products

For D. C. Switchboards

The Four Famous Fan-Shaped Instruments Familiar to Every Field

NO INSTRUMENTS ever designed have met with greater popularity and wider application to industrial requirements than the Weston D. C. Fan-Shaped models.

They are everywhere in evidence—on small control panels where they exercise efficient regulation over innumerable manufacturing processes; on medium and large sized switchboards in the power plants and control rooms of central stations and industrial establishments; in mining, marine and railway installations; and in all classes of field engineering and construction work—wherever there is a need for sturdy and reliable instruments of moderate price.

They are especially applicable to the electrical and mechanical requirements of signal and control systems where a number of standardized units are employed as shown in the illustration. Their compact shape and simplicity of mounting offer considerations of economical importance to the switchboard designer, while from an operating standpoint their long legible scales and bold uniform markings provide ease and accuracy in making quick readings.

There are four standard Fan-Shaped models, furnished as Voltmeters, Ammeters, Millivoltmeters and Milliammeters in a comprehensive list of ranges. Model 267 is designed for small switchboards and panels; Models 269 and 271 for medium-size switchboards; and Model 273 for standard switchboards. All instruments are of the surface type with back connections and are shielded from external magnetic fields. Accuracy, 1 per cent.

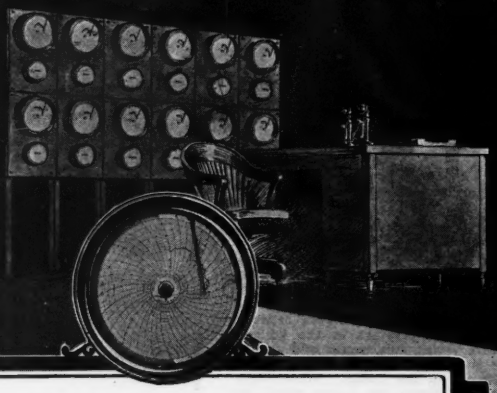
For complete description, electrical characteristics, ranges, etc., write for Bulletin No. 21.

WESTON ELECTRICAL INSTRUMENT CORPORATION

599 Frelinghuysen Ave., Newark, N. J.

Weston PIONEERS SINCE 1888 INSTRUMENTS

THE NIGHT



YOU leave your plant in the evening. As you pass the gate, the watchman bids you good-night. You leave with a feeling that your property is safe from intrusion or damage from the outside.

All through the night, within the walls of your plant, production continues. Does your night watchman give you the same feeling of security against internal waste—waste which gnaws at the very financial structure of your entire organization? Are you satisfied that carelessness is not creeping into your various departments, where the close supervision of daytime operation is not present?

Flow meters give you this assurance by making close supervision possible at all times. The operators know that in your office, day after day, night after night, the story of performance is faithfully recorded, uninterrupted by your presence or absence from the plant.

Bulletin "Steam Economy" mailed on request

REPUBLIC FLOW METERS COMPANY

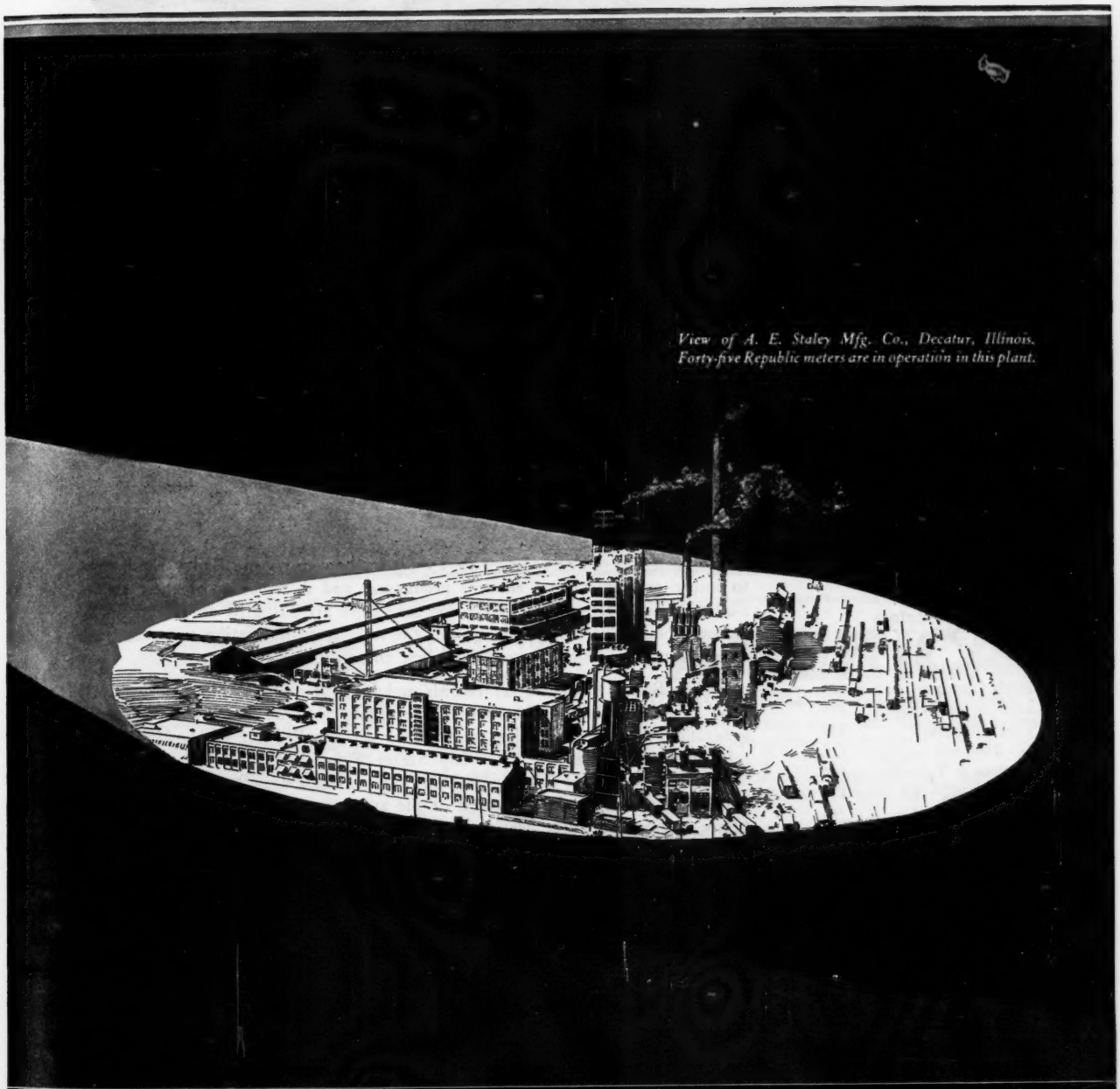
Executive offices and plant · 2224 Diversey Parkway · Chicago, Ill.

Branch Offices in 25 Principal Cities

DOMINION FLOW METERS CO., *Toronto, Canada* ELEKTROFLO, *Berlin, Germany* ELECTROFLO METERS CO., *London, England*

The REPUBLIC

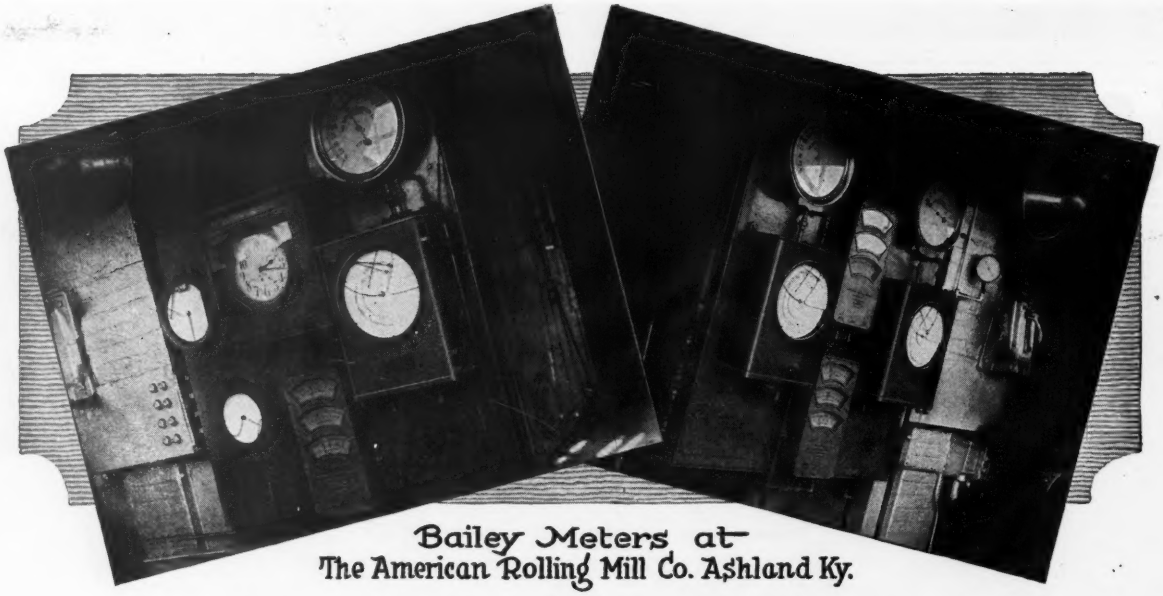
WATCHMAN



View of A. E. Staley Mfg. Co., Decatur, Illinois. Forty-five Republic meters are in operation in this plant.

REPUBLIC—ORIGINATORS OF THE ELECTRICALLY OPERATED FLOW METER

FLOW METERS



Bailey Meters at
The American Rolling Mill Co. Ashland Ky.

The Leading Steel Mills Use BAILEY METERS

Prominent Steel Mills Using Bailey Meters

Customer	Meters
Bethlehem Steel Company	362
Carnegie Steel Company	181
Jones & Laughlin Steel Corp.	178
National Tube Company	139
Illinois Steel Company	117
Youngstown Sheet & Tube Co.	160
American Steel & Wire Co.	110
Wheeling Steel Corporation	85
Weirton Steel Company	83
American Sheet & Tin Plate Co.	80
American Rolling Mill Co.	51
Otis Steel Company	50
Trumbull Steel Company	37
Republic Iron & Steel Co.	35
United Alloy Steel Co.	32
Inland Steel Company	27
Alan Wood Iron & Steel Co.	22
Crucible Steel Company	21
American Car & Foundry Co.	18
Andrews Steel Company	18
Donner Steel Company	15

The largest and most important steel mills in the country use Bailey Equipment to insure economical and efficient production and distribution of their steam. Bailey Boiler Meters and Multi-Pointer Gages are installed on all boilers so that the boiler operators will have all the necessary information to guide them in obtaining the desired capacity and best efficiency at all times.

The Bailey Boiler Meter records and integrates Steam Flow, records Air Flow and Flue Gas Temperature. The Steam Flow shows the rate of steam generation, and the Air Flow records the air supplied for combustion. The relation between the Air Flow and Steam Flow records shows whether the correct amount of air is being supplied for combustion. The Flue Gas Temperature Recorder makes a record of the average temperature of all the Flue Gases leaving the boiler heating surface. This gives a check on the condition of the heating surface and baffles, as the presence of scale, soot or defective baffles is reflected in an increase in the temperature.

Bailey Fluid Meters are used extensively for measuring the distribution of steam and water in steel plants. The superintendent of one large steel plant recently remarked that the installation of Bailey Fluid Meters on the steam lines to all departments had resulted in a very material reduction in steam cost, to the extent that the meters were paying for themselves every two weeks.

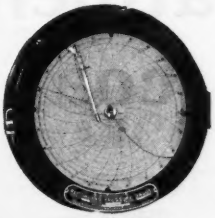
Bailey Gas Meters have been found very accurate and reliable for the measurement of coke oven gas.

Write for copy of New Bulletin No. 35

BAILEY METER CO.

1040 IVANHOE RD. CLEVELAND, OHIO.

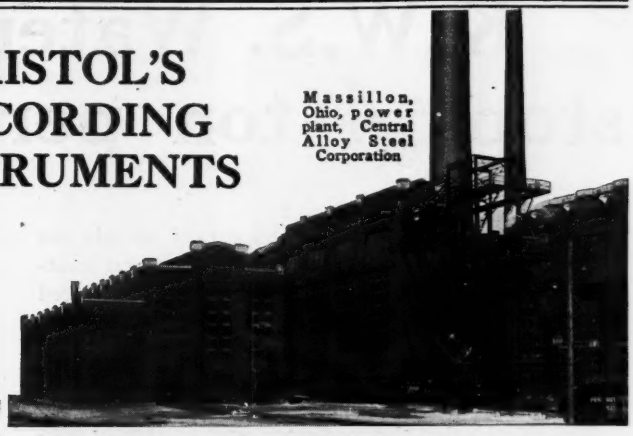
Bailey Meter Company Limited, Montreal, Quebec.



Round Type Bristol's Recording Pressure Gauge

Bristol's Recording Thermometer

BRISTOL'S RECORDING INSTRUMENTS



Massillon, Ohio, power plant, Central Alloy Steel Corporation

Show the way to greater efficiency in the generation of Power

BRISTOL'S — the name of a most extensive and highly perfected line of instruments that meet power plant and industrial requirements for records of Pressure, Vacuum, Temperature, Draft, Electricity, Speed, Humidity, etc.

Remarkably high combustion efficiency is obtained in the Northern Industrial Power Plant shown above at the Central Alloy Steel Corp., Massillon, Ohio, —manufacturers of high quality steel products. Blast furnace gas, pulverized coal and coke are burned; conditions of temperature, pressure, etc., being kept under constant surveillance with the use of Bristol's Recording Instrument equipment.

Bristol's Engineers are ready to assist you without cost or obligation in increasing operating efficiency through the correct application of instruments to power and industrial plant needs.

THE BRISTOL COMPANY, Waterbury, Connecticut

Akron, Birmingham, Boston, Chicago, Denver, Detroit, New York, Philadelphia, Pittsburgh, St. Louis, San Francisco

Send for free trial

on any underfeed stoker with a revolving shaft. See for yourself the savings a C. J. effects!

C. J. Manufacturing Co.
3427 N. 5th St., Philadelphia, Pa.

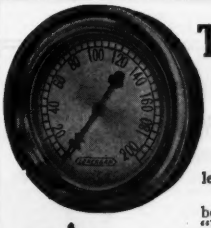
It costs you nothing to prove in your own plant that C. J. Coal Meters *will save you money*

AMERICAN
INDICATING PRESSURE GAUGES

for pressure, vacuum and draft. Have extra heavy, long-wearing, non-corrosive movement. Dial is hand calibrated, insuring accuracy. White enameled matt finish eliminates glare and makes reading easy. Write for Catalog A-34.

Consolidated Ashcroft Hancock Co., Inc.

American Schaeffer & Budenberg Division
338 Berry St., Brooklyn, N. Y.



The Lonergan Line
Steam, Water, Air, Gas and Ammonia Appliances

Each specialty shown is a leader in its line.

At left, B. O. E. Gauge and, below, Chime Whistle, Model "WV." "QC" Water gauge at right. Write.

J. E. LONERGAN CO.
Established 1872
213 Race Street, Philadelphia, Pa.
Export Office: Benj. Whittaker, Inc.
122 Greenwich St., New York

Corroding Out or Clogging Up

Which Are Your Water Systems Doing?

You may analyze and analyze but the results will not always prove the corrosive properties of the water. Only the Rice Detector can be trusted to absolutely expose the true conditions. It will tell you the complete story without a pause in your plant operation. Simply install the Detector and examine the sensitized rod at regular intervals. Any attendant can determine whether your water is corroding your equipment or creating deposits. And RICE analyses will scientifically prove the cause and RICE reports will point out the safe, sane, sure and immediate relief.

Ask for the Story of Rice Service and the Rice Detector

Cyrus Wm. Rice & Company
Water Chemists and Engineers
Highland Building Pittsburgh, Penna.

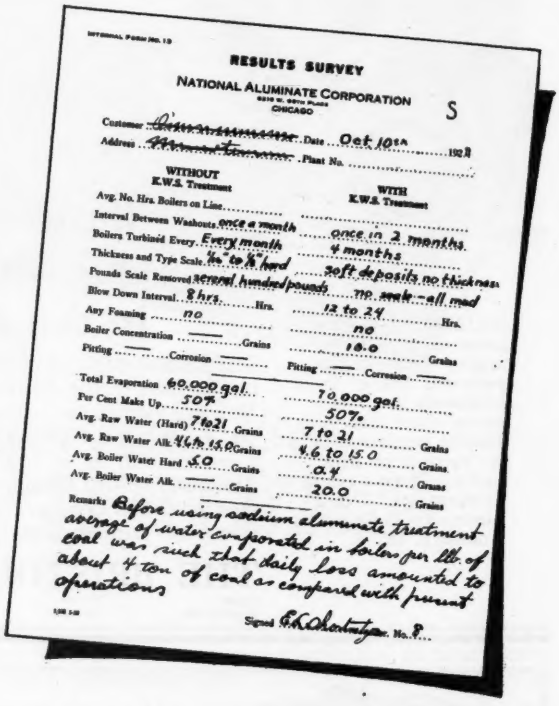
K.W.S. Water Treatment stops 4-ton per day coal loss

AGAIN an actual results survey reveals the remarkable efficiency of K.W.S. water treatment—before it was used the water evaporated per lb. of coal was such that the daily loss amounted to 4 tons of coal as compared with present conditions.

Notice that the conditions were extremely difficult—raw water hardness varying from 7 to 21 grains. No ordinary formula would work here, but the K. W. S. system, being flexible and controlled by daily tests, made certain that the correct treatment was used at all times.

Before K. W. S. was used the average boiler water hardness was 5 grains, but K. W. S. reduced it to 4/10 of a grain. Turbining is done now only 3 times a year and then only as a precaution as all scale has been eliminated. The washout interval was doubled and the blowdown lengthened from every 8 hours to 12 to 24 hours.

This is a very good example of the economies possible with K. W. S. and your ability to solve difficult water situations with this treatment. K. W. S. has demonstrated once more that it can make good water treatment better.



RESULTS SURVEY

NATIONAL ALUMINATE CORPORATION
6224 W. 66TH PLACE
CHICAGO

S

Customer [illegible] Date Oct 10th 1928

Address [illegible] Plant No.

	WITHOUT K.W.S. Treatment	WITH K.W.S. Treatment
Avg. No. Hrs. Boilers on Line		
Interval Between Washouts	once a month	once in 2 months
Boilers Turbined Every	Every month	4 months
Thickness and Type Scale	1/16" to 1/8" hard	soft deposits no thickness
Pounds Scale Removed	several hundred pounds	no scale - all mud
Blow Down Interval	8 hrs. Hrs.	12 to 24 Hrs.
Any Foaming	no	no
Boiler Concentration Grains		18.0 Grains
Pitting Corrosion		Pitting Corrosion
Total Evaporation	60,000 gal.	70,000 gal.
Per Cent Make Up	50%	50%
Avg. Raw Water (Hard) Grains	7 to 21	7 to 21
Avg. Raw Water Alk. Grains	4.6 to 15.0	4.6 to 15.0 Grains
Avg. Boiler Water Hard Grains	5.0	0.4 Grains
Avg. Boiler Water Alk. Grains		20.0 Grains

Remarks: Before using sodium aluminate treatment average of water evaporated in boiler per lb. of coal was such that daily loss amounted to about 4 ton of coal as compared with present operations

Signed E. K. Chantaye No. 8

Treat your water right and it will treat you right

This advertisement is one of a series showing results achieved by K. W. S. Sodium Aluminate and the K. W. S. system of water treatment used in both external and internal treating for steam plants, and distilled or raw water ice plants. We will be glad to send you copies of recent results surveys made, or any literature covering particular conditions in which you are interested. The coupon is for your convenience.

K.W.S.
REG. U.S. PAT. OFF.
SODIUM ALUMINATE

NATIONAL ALUMINATE CORPORATION
CHICAGO
6224 W. 66th Place

Specialists in water softening, filtration, process work, waste water disposal, and all problems involving water supply and treatment. Manufacturers of National dry chemical feeders.

Representatives in Principal Cities

(Please check, sign, and mail)

National Aluminate Corporation,
6224 W. 66th Place, Chicago, Illinois.

☐ You may survey our water condition.

☐ You may send a representative to explain K. W. S. service.

You may send literature on:

☐ External treatment of boiler water.

☐ Internal treatment of boiler water.

Name .....

Address .....

Company .....

PPE 12-15-Gray

Get this

new booklet on how to prevent boiler troubles!

THIS attractive booklet explains "Magic" and how for ***Twenty-Five Years*** it has prevented scale, corrosion and pitting in boilers

MAGIC

Mailed on request

GARRATT-CALLAHAN CO.

San Francisco — Chicago — New York

MAGIC BOILER "The FILM of PROTECTION for BOILERS" PRESERVATIVE

Two Minutes— *a day will keep your feedwater clean*

"None better than the best"

30 years of "Know How"

One pound of the correct Hawk-Eye Compound, fed to a 100 horsepower boiler keeps scale away—and we loan the device for feeding without cost. Write.

HAWK-EYE COMPOUND CO.
(Not Inc.)
Blue Island, Illinois

HAWK-EYE COMPOUNDS

Six Reasons for Installing

FILTRATORS

the NON-CHEMICAL apparatus for treating boiler feed are:

1. Prevention of formation of scale in boiler, piping systems, condensers, etc.
2. Removal of existing scale.
3. Prevention of pitting and corrosion.
4. Counteraction of the effect of lubricating oil getting into boilers.
5. Simplicity of installation and low cost of upkeep.
6. Harmlessness to boiler and fittings.

Write for information

FILTRATORS COMPANY, Inc.
96 Liberty St., New York

Payroll cut 30% and time halved

. . . by cleaning up coal dust this Sturtevant way!

WITH fewer men . . . in half the time . . . three hustling Sturtevant Vacuum Cleaners thoroughly clean up pulverized coal dust at the plant of the Narragansett Electric Co., Providence, R. I.

Five hose lines operating from each cleaner capture every speck of dust. Time and labor is saved . . . cleaning expenses are reduced 30%.

Hard-to-get-at places—equipment—even windows—are easily kept dust free. Floors, walls, piping, ceilings are cleaned regularly at lower cost.

Such economy is typical of Sturtevant cleaned plants. It will pay you to investigate this Sturtevant cleaning method. Write to our nearest office for full details.

B. F. STURTEVANT CO., Hyde Park, Boston, Mass.
Branch Offices in Principal Cities
Canadian Offices at: Toronto, Montreal and Galt
Also Agents in Principal Foreign Countries

Sturtevant
REG. U.S. PAT. OFF.
Portable and Stationary
Vacuum Cleaners

What Is
DUST
Costing You?

Nielsen Survey on Tabco

28% on the investment is paid yearly by this Tabco Pneumatic Cleaning System in a typical power plant.

Actual installation and operating costs are given in this Nielsen Survey.

You can estimate, from these figures, what a Tabco System might cost for your plant, and what it *would save* for you.

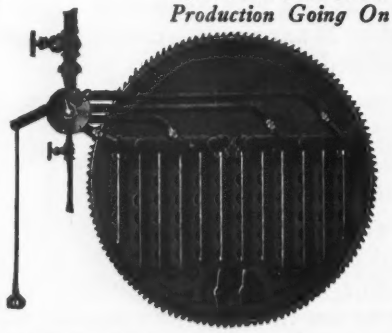
Would you like a copy of the survey?

TABCO
PNEUMATIC
CLEANING SYSTEMS
"Take all the dust and leave a profit"

ALLEN & BILLMYRE CO., INC.
728 Grand Central Palace, New York City
Representatives in principal cities

Every Boiler Tube Swept Clean of Soot—

With the Front Doors Closed and Full Steam Production Going On



NATIONAL Soot Blowers

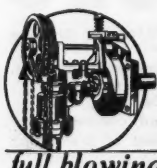
Designed for the boilers in which they are installed. A master valve placed at a convenient point controls the steam flow through the nozzles placed in front of every tube in the boiler. Simple, easy and absolutely clean to operate. No juggling with a scaldingly hot steam lance. No heavy labor. No dust or burns. Firemen never shirk cleaning in the National way.
You need not be told what clean boiler tubes can save in fuel. The thing to do is to have clean tubes by installing the National Soot Blower on every boiler. A 30 days' free trial will prove that you can run your boilers at a material saving.

Furnished for return tubular, Scotch Marine and Economic boilers. Bulletin on request.

National Flue Cleaner Company, Inc.
8 Church Street Groveville, N. J.

THE MARION LINE
SOOT BLOWERS STOKERS GRATES
Save the coal
MARION MACHINE, FOUNDRY & SUPPLY CO.
MARION, INDIANA

To Reduce Fuel Bills
equip with



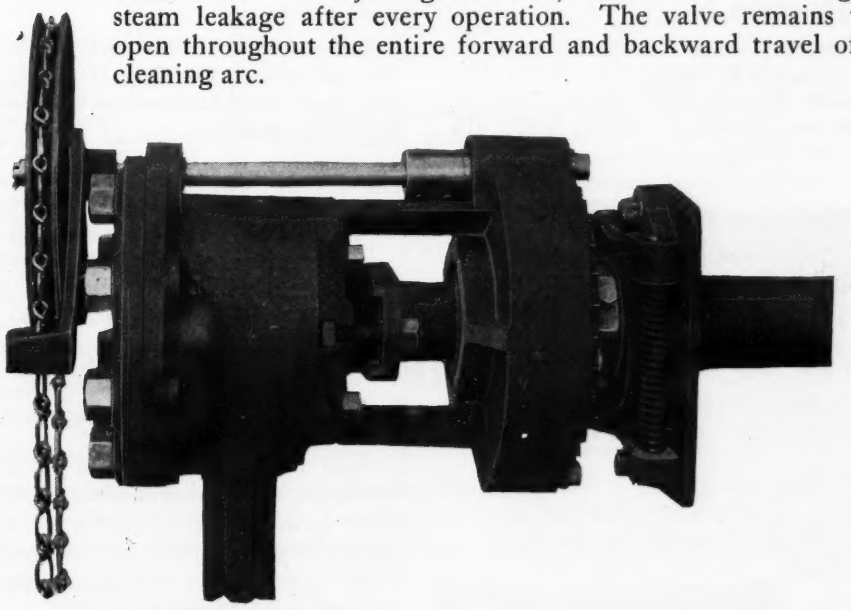
BAYER SOOT BLOWERS
full blowing force properly directed

THE BAYER COMPANY
1506 South Grand Blvd.
St. Louis, Mo., U. S. A.

The Improved VULCAN Valve Operating Head

Type "H"

The sliding disk valve is inside of and is an integral part of the head. It is self-adjusting for wear, and seals the head against steam leakage after every operation. The valve remains wide open throughout the entire forward and backward travel of the cleaning arc.



QUICKLY MOUNTED. The head is attached to the element by means of four studs passing through a flange. This makes it possible to fully mount the new Vulcan head in about FIFTEEN MINUTES and to dismount it in about one-half of that time.

Other features are the complete accessibility for inspection; enclosed gears: and the location of the chain wheel in a plane far enough away from the boiler wall for the chain to clear the steel work on the side of the boiler.

The new Vulcan Valve Operating Head, Type "H" will be installed on the boilers of the new State Line Generating Plant at Hammond, Ind., Sargent & Lundy, Chicago, engineers.

Write for new Bulletin

The VULCAN SOOT CLEANER COMPANY

MAIN OFFICE DU BOIS PA OFFICES IN THIRTY CITIES

Ever Consider the Dean?

Really consider it—not merely *guess* what it will do?

Did you ever get our literature and *post* yourself on the Dean?

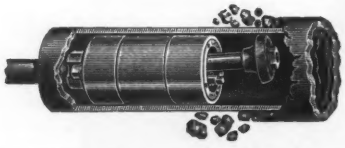
Ever find out who are using it—and with what results?

Ever *try* the Dean?

Can you afford not to?

Listen!

A concern in Royersford, Pa., tried the Dean in a boiler they thought clean—tried it simply because we told them they'd better do



The Dean removing scale from the tube of a return tubular boiler

it to be on the safe side—and this is what they wrote:

> *"You win. Today we took 825 pounds of scale from a boiler we thought clean. Please send bill."*

A concern in Cleveland, Ohio, thought boiler compounds were solving their scale problem. Because they were willing to give the Dean a trial they are *now saving* $50.00 a month. Note what they say:

> *"The cleaner is working very satisfactorily indeed and we have discontinued the use of boiler compound which was costing us in the neighborhood of $50.00 per month."*

One of the largest corporations in the country was looking for the *best* tube cleaner for water tube boilers. Everybody around the plant said the best way to clean a water tube was to bore out the scale. One man said, "It

(e) The Dean removing scale from the tube of a water tube boiler.

won't hurt to try the Dean; why not try it with the others?" So they tried it. Here's what the superintendent wrote after all the cleaners had been tested:

> *"We find that your cleaner has given better satisfaction than any cleaner for water tubes we have tried. We have experimented with several different cleaners this spring and yours has given us the best results. It cleans the tubes more thoroughly than any we have tried."*

Didn't it *pay* these people to try the Dean?

You have that same opportunity—the opportunity to find out the actual condition of your boilers—the opportunity to test the efficiency of your compounds and water treatments—the opportunity to compare the Dean's work with that of other cleaners.

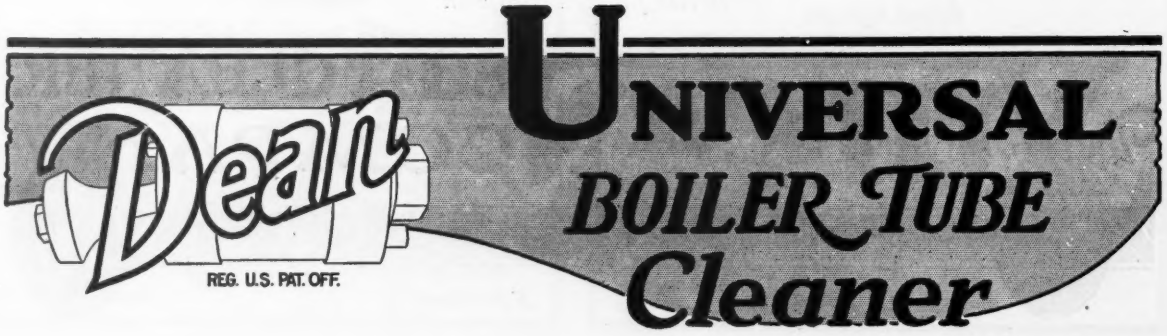
Why not take advantage of it?

FREE TRIAL OFFER

We'll lend you a Dean for free trial in one boiler. We won't hurry you with the test, force the cleaner on you, nor get riled if we don't effect a sale. We simply want you to see what a money-saving proposition we have. Then it's up to you to decide what to do with it.

THE WM. B. PIERCE CO.

149 Ellicott St. Buffalo, N. Y.



★

It's the Last Thin Layer of Soot that wastes the most fuel—and Pilley gets it!

Pilley Pointers

1. Greater Boiler Capacity
2. Dependable Steam Output
3. Lower Fuel Bills
4. Reduces Boiler Maintenance
5. Cuts Down Shutdowns
6. Makes Boilers Last Longer
7. Simple and Compact
8. Reduces Labor Costs
9. Practically Indestructible
★ 10. Adjustable to Fit the Tubes.

Soot is the champion insulator! Even a layer of soot one one-hundredth of an inch thick will stop approximately as much heat as 10 inches of iron. And only too often the caked-on soot is not removed with the ordinary cleaner.

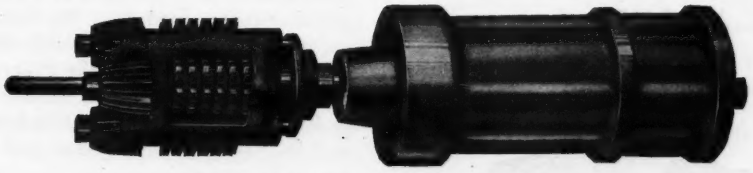
Because the Pilley Combination Flue Brush and Scraper is adjustable to the FULL diameter of the tube, the heavy scraper blades backed up by spring steel cut the hardest incrustations of soot right down to the tube metal. Then the strong, tempered wire brush sweeps the soot before it.

Order a Pilley from your jobber. We guarantee results. And at $1.00 per diameter inch, often a Pilley pays for itself in one cleaning in the fuel, time and labor it saves.

PILLEY PACKING & FLUE BRUSH MFG. CO.
611 South Third Street, St. Louis, Mo.
Eastern Office: 71 Fulton Street, New York

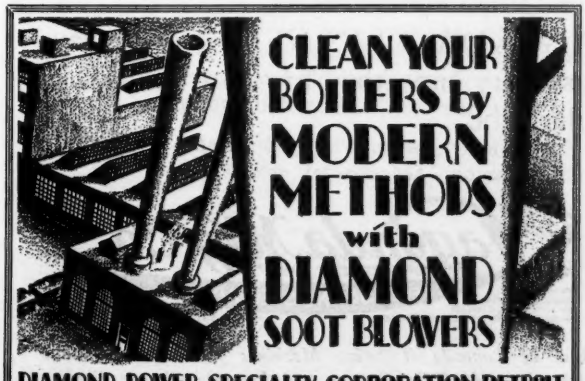
PILLEY *Combination* FLUE BRUSH *and* SCRAPER

On an EIGHT-BOILER BATTERY by cleaning FOUR TIMES A YEAR, the ANNUAL CLEANING TIME was REDUCED from 28 to 18 DAYS. This also enabled the plant to CARRY ITS LOAD WITH SEVEN CLEAN BOILERS, leaving the EIGHTH AS A SPARE!



Roto 4" Heavy Duty air-driven Tube Cleaner

THE ROTO COMPANY, Sussex Avenue and Newark Street, NEWARK, N. J.



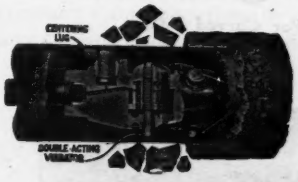
CLEAN YOUR BOILERS by MODERN METHODS with DIAMOND SOOT BLOWERS

DIAMOND POWER SPECIALTY CORPORATION-DETROIT

TORPEDO Rids the Tubes of Scale

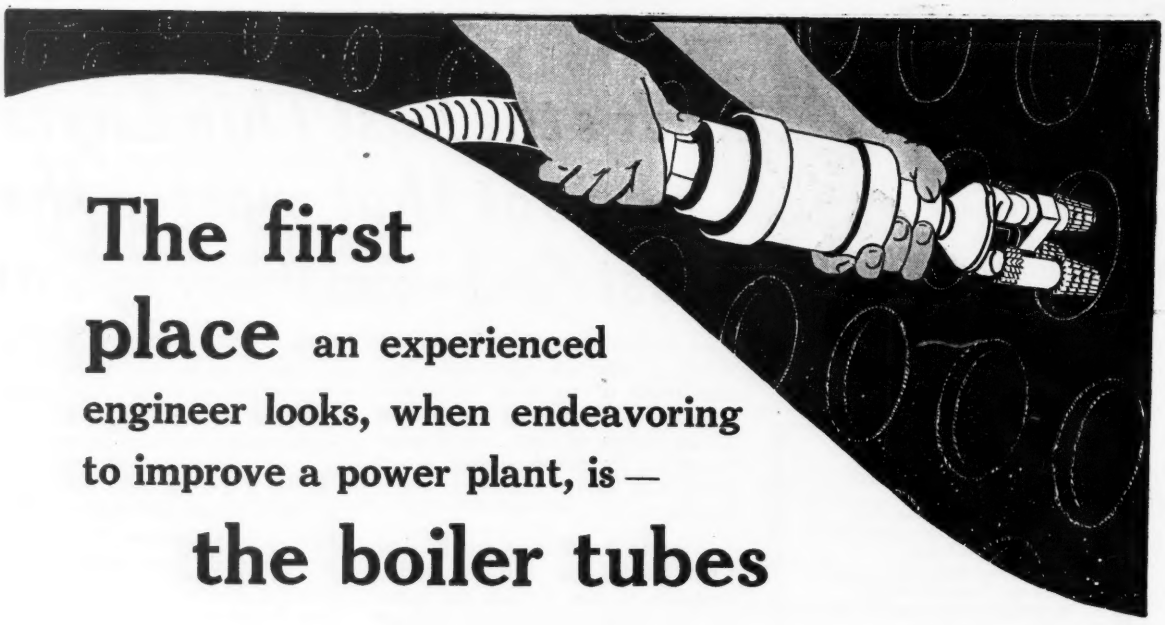
Shake it off. That's the sure way. You can't burn or soak scale out of boiler tubes, but vibration is resistless.

The "Torpedo" will do it for you rapidly. It taps the tubes 11,000 times a minute—no pounding or hammering. Scale cracks and falls off. Being brittle it cannot stand the vibration. No injury to tubes, however.



Try a "Torpedo" once and be convinced of its merit. You can have one for a free trial. Just write us.

The General Specialty Company
70 Carroll Street Buffalo, N. Y.

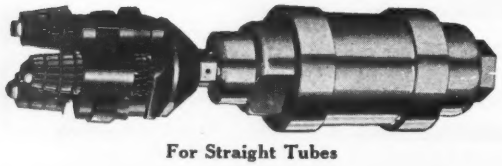


The first place an experienced engineer looks, when endeavoring to improve a power plant, is — the boiler tubes

LAGONDA CLEANERS

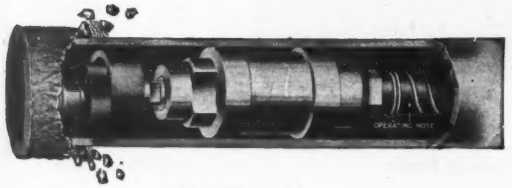
Keep boiler tubes in prime condition

There's a LAGONDA for your tubes, no matter what size or type



For Straight Tubes

For Curved Tubes



For Fire Tubes

Numerous things can be done to revamp an old or inefficient power plant. One of the first things to investigate is the condition of the boiler tubes.

A recent article in Power told of the revamping of the Ingersoll Watch plant. Quoting from this article:

> "A preliminary study of the steam generating plant showed an evaporation of 6 lbs. of water per pound of coal as fired . . . An examination of the boilers showed them to be considerably scaled, and it was decided to turbine the boilers . . . After the boilers were turbined, a considerable saving in coal was realized, the evaporation being brought up to 8 lbs. of water per pound of coal as fired."

Certainly a simple and inexpensive way to obtain a 33-1/3 per cent increase in boiler efficiency.

LAGONDA CLEANERS create savings every time they are run through a boiler tube.

The Lagonda Mfg. Co.
SPRINGFIELD, OHIO
FUEL SAVING SPECIALISTS
NEW YORK, CHICAGO, PHILADELPHIA, BOSTON, PITTSBURGH, CLEVELAND, CINCINNATI, DETROIT, SYRACUSE, BALTIMORE, ATLANTA, SAN FRANCISCO, MONTREAL, LONDON, ST. LOUIS, KANSAS CITY, DENVER, DALLAS.

Makers of Lagonda Reseating Machines for boiler caps and headers, Lagonda Tube Cutters, and Lagonda Cleaner Feeding Device for curved tube boilers. X-1444

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Labor Reducing Equipment

The past decade has been marked by increased attention to reducing the cost of handling fuel by mechanical means, increasing combustion efficiency by better fuel preparation methods, insuring continuous operation and lowering the price paid by seasonal storage and reclamation.

Great problems have been solved in this branch of the field during recent years. Today, automatic machinery handles fuel and ash. Gone are the days when men with shovels and barrows can compete with mechanical equipment in power plants.

Only the surface has been cultivated in this part of power plant economy. Thousands of plants remain to be rebuilt, re-equipped and improved with modern mechanical equipment and improved operating methods.

The market for machinery and equipment for this work is unbounded, the opportunities for engineers to plan such improvements are unlimited and the savings that may be effected by these means are beyond comparison with those already made.

The next issue of Power Plant Engineering will be the 21st Annual Reference and Textbook Number and it will be specialized on Fuel Handling, Storage and Preparation.

This January 1, 1929, Feature Number will treat the subject exhaustively and with the authoritativeness that has made each of Power Plant Engineering's Annual Reference and Textbook Numbers the outstanding publication of the year.

The synopsis of contents, published in the December 1st number, indicated the value of the January 1st Number to its readers.

Manufacturers will show every type of machinery, equipment and supplies required for modern power plants in the advertising pages of this number.

In past years orders for extra copies of these January 1st Specialized Numbers have been received from consulting and designing engineers who are responsible for improvements in plants, and for the machinery, equipment and supplies used in them, as well as from many power companies for the use of their different department heads.

To avoid disappointment it is suggested that you see that your annual subscription is entered and extra copies ordered at once so that a sufficiently large edition may be printed. All regular subscribers will receive this number as a part of their yearly subscription.

The annual subscription to Power Plant Engineering, 24 issues, including the January 1st Specialized Number, is $2.00 a year. Extra copies of the January 1 Number on "Fuel Handling, Storage and Preparation" are 50 cents each, postage prepaid.

Send remittances and orders for both annual subscriptions and extra copies direct to the Technical Publishing Company, 53 West Jackson Boulevard, Chicago, Ill.

Printing on the January 1, 1929, Fuel Handling, Storage and Preparation Number commences on December 15, after which time the edition cannot be enlarged. Therefore we urge you to consider your requirements for executives or special reference use and order extra copies at once.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allen & Billmyre Co., Inc., N. Y.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem.
Binks Spray Equip. Co., Chicago.
Chicago Pneumatic Tool Co., New York, N. Y.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner-Denver Co., Quincy, Ill.
Nash Engrg. Co., South Norwalk, Conn.
Sullivan Machy. Co., Chicago.
Worthington Pump & Mach. Corp., New York.

AIR COOLERS
Griscom-Russell Co., New York.

AIR PREHEATERS
Air Preheater Corp., New York.
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Buffalo Forge Co., Buffalo, N. Y.
Combustion Engrg. Corp., N. Y.
Foster Wheeler Corp., N. Y.
Prat-Daniel Corp., New York.

AIR WASHERS
Buffalo Forge Co., Buffalo, N. Y.
Nichols Products Corp., N. Y.

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Northern Equipment Co., Erie.
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McLeod & Henry Co., Troy, N. Y.
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Magnolia Metal Co., New York.

BEARINGS
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Stephens-Adamson Mfg. Co., Aurora, Ill.

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Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.

BELT LACING
Flexible Steel Lacing Co., Chicago.

BELTING
Crandall Pkg. Co., Palmyra, N.Y.
Quaker City Rubber Co., Phila.

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Air Preheater Corp., New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Prat-Daniel Corp., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

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Sturtevant Co. B. F., Boston.

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Ideal Commutator Dresser Co., Sycamore, Ill.
Sturtevant Co., B. F., Boston.

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Ideal Commutator Dresser Co., Sycamore, Ill.

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Carling Turbine Blower Co., Worcester, Mass.

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Buffalo Forge Co., Buffalo.

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Schutte & Koerting Co., Phila.

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Diamond Power Spec. Corp., Detroit, Mich.
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National Flue Cleaner Co., Inc., Groveville, N. J.
Vulcan Soot Cleaner Co., Dubois, Pa.

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BOILER BAFFLE CONTRACTORS
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Pierce Co., Wm. B., Buffalo.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Roto Co., The, Newark, N. J.

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National Tube Co., Pittsburgh.

BOILERS
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Combustion Engrg. Corp., N. Y.
Connelly Boiler Co., The D., Cleveland, O.
Erie City Iron Works, Erie, Pa.
Hedges-Walsh-Weidner Co., New York, N. Y.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Titusville Iron Works Co., Titusville, Pa.
Union Iron Wks., Erie, Pa.
Vogt Machine Co., Inc., Henry, Louisville, Ky.
Wickes Boiler Co., Saginaw.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 170

BOILER BAFFLES
Boiler Engrg. Co., Newark, N. J.
King Refrac. Co., Inc., Buffalo.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., N. Y.

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Dampney Co. of Am., Boston.

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Griscom-Russell Co., New York.

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Quigley Furnace Spec. Co., N. Y.

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Rust Engrg. Co., Pittsburgh.
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Edge Moor Iron Co., Edge Moor.
Titusville Iron Works Co., Titusville, Pa.

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Edge Moor Iron Co., Edge Moor.
Wickes Boiler Co., Saginaw.

BOILERS, WATER TUBE
Babcock & Wilcox Co., The, N.Y.
Combustion Engrg. Corp., N. Y.
Edge Moor Iron Co., Edge Moor.
Hedges-Walsh-Weidner Co., New York, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Titusville Iron Works Co., Titusville, Pa.
Wickes Boiler Co., Saginaw.

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Hays School of Combustion, Chicago.

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Prat-Daniel Corp., New York.

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Norton Co., Worcester, Mass.

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Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

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Fairfield Engrg. Co., Marion, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.

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Blaw-Knox Co., Pittsburgh, Pa.
Jeffrey Mfg. Co., Columbus, O.

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Wellman-Seaver-Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET
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McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Quigley Furnace Spec. Co., N. Y.

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Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE
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CHEMICALS, WATER TREATING
National Aluminate Corp., Chicago, Ill.

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American Chimney Corp., N. Y.
Kellogg Co., The M. W., N. Y.
Prat-Daniel Corp., New York.
Rust Engrg. Co., Pittsburgh.
Springfield Boiler Co., Springfield, Ill.
Wiederholdt Construction Co., St. Louis, Mo.

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Allen-Sherman-Hoff Co., Phila.
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Wellman-Seaver-Morgan Co., The, Cleveland, Ohio.

CHARLES A COFFIN MEDAL
FOR DISTINGUISHED CONTRIBUTION
TO THE DEVELOPMENT OF ELECTRIC
LIGHT AND POWER FOR THE CONVEN
IENCE OF THE PUBLIC AND THE
BENEFIT OF THE INDUSTRY
AWARDED TO

DURING the six years of the Charles A. Coffin Foundation for annually rewarding excellence in the operation of electrical utilities, the Gold Medal has been won three times by companies under the executive management of Stone & Webster, Inc. The successful companies are Northern Texas Traction Company, Puget Sound Power & Light Company, and Virginia Electric and Power Company.

STONE & WEBSTER
INCORPORATED

OPERATE FINANCE BUILD

COAL WEIGHING AND MEASURING EQUIPMENT
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C-J Mfg. Co., Philadelphia.

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Dart Mfg. Co., E. M., Providence, R. I.
Homestead Valve Mfg. Co., Coraopolis, Pa.

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Grinnell Co., Inc., Providence.
National Pipe Bending Co., New Haven, Conn.

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Hagan Corp., Pittsburgh, Pa.

COMBUSTION ENGINEERS
Boiler Engrg. Co., Newark, N. J.
Hagan Corp., Pittsburgh, Pa.

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Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago, Ill.

COMMUTATOR CEMENT
Ideal Commutator Dresser Co., Sycamore, Ill.

COMMUTATOR DRESSER
Ideal Commutator Dresser Co., Sycamore, Ill.

COMMUTATOR SLOTTERS
Ideal Commutator Dresser Co., Sycamore, Ill.

COMMUTATOR STONES
Ideal Commutator Dresser Co., Sycamore, Ill.

COMPOUND PIPE JOINT
Dixon Crucible Co., Jos., Jersey City, N. J.
Smooth-On Mfg. Co., Jersey City.

CONCRETE ARMORING SURFACE
Irving Iron Works Co., Long Island City, N. Y.

CONDENSER TUBE CLEANERS
Lagonda Mfg. Co., Springfield, O.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CONDENSERS
Bethlehem Steel Co., Bethlehem.
Binks Spray Equip. Co., Chicago.
Chicago Pneumatic Tool Co., New York, N. Y.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Gradon Mfg. Co., Philadelphia.
Kellogg Co., The M. W., N. Y.
Manistee Iron Works, Manistee.
Schutte & Koerting Co., Phila.
Superheater Co., New York.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

CONSULTING ENGINEERS
Stone & Webster, Inc., Boston.

CONVEYORS
Combustion Engrg. Corp., N. Y.
Detrick Co., M. H., Chicago.
Fairfield Engrg. Co., Marion, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.

COOLERS, OIL
Griscom-Russell Co., New York.
Schutte & Koerting Co., Phila.

COOLING SYSTEMS
Binks Spray Equip. Co., Chicago.
Marley Co., The, Kansas City.
Sturtevant Co., B. F., Boston.
Yarnall-Waring Co., Phila.

COOLING TOWERS
Foster Wheeler Corp., New York.
Wheeler Mfg. Co., C. H., Phila.

CORROSION PREVENTIVES
Dampney Co. of Am., Boston.

COUNTERS, REVOLUTION
Lonergan Co., J. E., Phila., Pa.

COUPLINGS, COMPRESSION SHAFT
Nicholson & Co., W. H., Wilkes-Barre, Pa.

COUPLINGS, FLEXIBLE
Frederick Iron & Steel Co., Frederick, Md.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

COUPLINGS, TUBE
Parker Appliance Co., Cleveland.

COUPLINGS, UNION
Central Forging Co., Catawissa, Pa.
Dart Mfg. Co., E. M., Providence, R. I.
Grinnell Co., Inc., Providence.
Walworth Co., Boston.

CRANES, CRAWLING AND LOCOMOTIVE
Link-Belt Co., Chicago, Ill.

CRUSHING AND GRINDING MACHINERY
Pennsylvania Crusher Co., Phila.

DEAERATORS
Elliott Co., Jeannette, Pa.

DESIGNERS & BUILDERS, POWER PLANT
Stone & Webster, Inc., Boston.

DETECTOR, CORROSION
Rice & Co., Cyrus Wm., Pittsburgh, Pa.

DRYERS, ROTARY AND WASTE HEAT
Fuller Lehigh Co., Fullerton, Pa.

DUST COLLECTORS
Nichols Products Corp., N. Y.

DUST SWEEPING SYSTEMS
Allen & Billmyre Co., Inc., N. Y.

DYNAMOS AND MOTORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Engberg's Elec. & Mech. Wks., St. Joseph, Mich.
Fairbanks, Morse & Co., Chicago.
Terry Steam Turbine Co., Hartford, Conn.

ECONOMIZERS
Babcock & Wilcox Co., The, N.Y.
Foster Wheeler Corp., N. Y.

ECONOMIZERS, FUEL
Sturtevant Co., B. F., Boston.

EJECTORS
Elliott Co., Jeannette, Pa.
Penberthy Injector Co., Detroit.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Phila.

EJECTORS, SEWAGE
Nash Engrg. Co., South Norwalk, Conn.

ELECTRICAL SUPPLIES
Ideal Commutator Dresser Co., Sycamore, Ill.

ELECTRICAL WIRES AND CABLES
American Steel & Wire Co., Chicago and New York.

ELEVATORS
Otis Elevator Co., New York.

ELIMINATORS, AUTO, STEAM
Nicholson & Co., W. H., Wilkes-Barre, Pa.

ENGINE STOPS, AUTOMATIC
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

ENGINES, GAS AND GASOLINE
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Chicago Pneumatic Tool Co., New York, N. Y.
Fairbanks, Morse & Co., Chicago.
Sterling Eng. Co., Buffalo.
Titusville Iron Works Co., Titusville, Pa.
Worthington Pump & Mach. Corp., New York.

ENGINES, OIL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem.
Chicago Pneumatic Tool Co., New York, N. Y.
Fairbanks, Morse & Co., Chicago.
Sterling Eng. Co., Buffalo.
Worthington Pump & Mach. Corp., New York.

ENGINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
De Laval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Engberg's Elec. & Mech. Wks., St. Joseph, Mich.
Erie City Iron Wks., Erie.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Boston.
Titusville Iron Works Co., Titusville, Pa.
Troy Eng. & Mach. Co., Troy, Pa.

EVAPORATORS
Foster Wheeler Corp., New York.
Gradon Mfg. Co., Philadelphia.

EVAPORATORS, WATER
Griscom-Russell Co., New York.

EXHAUST HEADS
Burt Mfg. Co., The, Akron, O.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sims Co., The, Erie, Pa.
Swartwout Co., Cleveland.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit.

EXHAUSTERS
Buffalo Forge Co., Buffalo.

EXPANDERS, TUBE
Nicholson & Co., W. H., Wilkes-Barre, Pa.

EXTRACTORS, OIL AND GREASE
Patterson-Kelley Co., The, N. Y.
Sims Co., The, Erie, Pa.

FANS, ELECTRIC
Buffalo Forge Co., Buffalo.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
Wing Mfg. Co., L. J., New York.

FANS, EXHAUST AND VENTILATING
Buffalo Forge Co., Buffalo.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
Prat-Daniel Corp., New York.
Sturtevant Co., B. F., Boston.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.

FEED WATER FILTERS
Filtrators Co., Inc., New York.

FEED WATER HEATERS AND PURIFIERS
Bethlehem Steel Co., Bethlehem.
Cochrane Corp., Philadelphia.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Gradon Mfg. Co., Philadelphia.
Griscom-Russell Co., New York.
Hoppes Mfg. Co., Springfield, O.
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley Co., The, N. Y.
Schutte & Koerting Co., Phila.
Sims Co., The, Erie, Pa.
Superheater Co., The, New York.
Swartwout Co., Cleveland.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

FEED WATER TREATMENT
Dearborn Chemical Co., Chicago.
Filtrators Co., Inc., New York.
Garratt-Callahan Co., Chicago.
Griscom-Russell Co., New York.
National Aluminate Corp., Chicago, Ill.

FEED WATER TREATMENT SERVICE
Rice & Co., Cyrus Wm., Pittsburgh, Pa.

FILTERS, AIR
Allen & Billmyre Co., Inc., N. Y.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 170

FILTERS, OIL
Burt Mfg. Co., The, Akron, O.
Sims Co., The, Erie, Pa.

FILTERS, WATER
Cochrane Corp., Philadelphia.
Filtrators Co., Inc., New York.

FIRE BRICK
Harbison-Walker Refract. Co., Pittsburgh, Pa.
King Refrac. Co., Inc., Buffalo.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., N. Y.

FIRE BRICK CEMENT
McLeod & Henry Co., Troy, N. Y.

FIRE CLAY
Carborundum Co., The, Perth Amboy, N. J.
Lavino and Co., E. J., Phila., Pa.

FIRE HYDRANTS
Howard Iron Works, Buffalo.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.

FITTINGS, FLANGE AND PIPE
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Grinnell Co., Inc., Providence.
Kellogg Co., The M. W., N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Walworth Co., Boston.

FLANGES
Dart Mfg. Co., E. M., Providence, R. I.

FLOATS
Reliance Gauge Column Co., Cleveland.

FLOORING, NON-SLIPPING
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

FLOORING, OPEN STEEL
Blaw-Knox Co., Pittsburgh, Pa.
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

FLOORING, STEEL
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

FLOORING, VENTILATING
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

FLOW METERS
Bailey Meter Co., Cleveland, O.
Republic Flow Meters Co., Chicago, Ill.

FLUE CLEANERS
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Co., Detroit, Mich.
General Specialty Co., Buffalo.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
National Flue Cleaner Co., Inc., Groveville, N. Y.
Pierce Co., Wm. B., Buffalo.
Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.
Vulcan Soot Cleaner Co., Du Bois, Pa.

FLUE SCRAPERS
Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.

FURNACE BOTTOMS, CAST IRON, AIR-COOLED
Allen-Sherman-Hoff Co., Phila.

FURNACE CONSTRUCTION AND REPAIR
Pilbrico Jointless Firebrick Co., Chicago, Ill.

FURNACE FIRE OBSERVERS
Springfield Boiler Co., Springfield, Ill.

FURNACE SURFACES, WATER COOLED
Combustion Engrg. Corp., New York, N. Y.
Fuller Lehigh Co., Fullerton, Pa.
Superheater Co., New York.

FURNACE WALLS
Combustion Engrg. Corp., N. Y.
Hedges-Walsh-Weidner Co., New York, N. Y.
Lavino and Co., E. J., Phila., Pa.
Superheater Co., New York.

FURNACES
Combustion Engrg. Corp., N. Y.
Erie City Iron Works, Erie, Pa.
Mc Clave-Brooks Co., Scranton.
Riley Stoker Corp., Worcester, Mass.

GAS PRODUCERS
Wellman-Seaver-Morgan Co., The, Cleveland, O.

GASKETS
Crandall Pkg. Co., Palmyra, N.Y.
"Flexitallic" Gasket Co., Camden, N. J.
Garlock Pkg. Co., Palmyra, N.Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Johns-Manville Corp., New York.
Metallo Gasket Co., New Brunswick, N. J.
Quaker City Rubber Co., Phila.
Smooth-On Mfg. Co., Jersey City.

GASKETS, ASBESTOS, STEEL
"Flexitallic" Gasket Co., Camden, N. J.

GATES, ASH
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.

GAUGE COCKS
Lonergan Co., J. E., Phila., Pa.
Penberthy Injector Co., Detroit.
Reliance Gauge Column Co., Cleveland.

GAUGE GLASSES
Jenkins Bros., New York, N. Y.

GAUGE TESTERS
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.

GAUGES, DIFFERENTIAL
Bailey Meter Co., Cleveland, O.

GAUGES, DRAFT
Bailey Meter Co., Cleveland, O.
Bristol Co., The, Waterbury.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago.

GAUGES, LIQUID LEVEL
Bristol Co., The, Waterbury.
Republic Flow Meters Co., Chicago.

GAUGES, PRESSURE AND RECORDING
Bristol Co., The, Waterbury.
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.
Lonergan Co., J. E., Phila., Pa.

GAUGES, WATER
Hedges-Walsh-Weidner Co., New York, N. Y.
Lonergan Co., J. E., Phila., Pa.
Penberthy Injector Co., Detroit.
Reliance Gauge Column Co., Cleveland.
Yarnall-Waring Co., Phila.

GEARS, DOUBLE HELICAL
De Laval Steam Turbine Co., Trenton, N. J.

GEARS, REDUCTION
De Laval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

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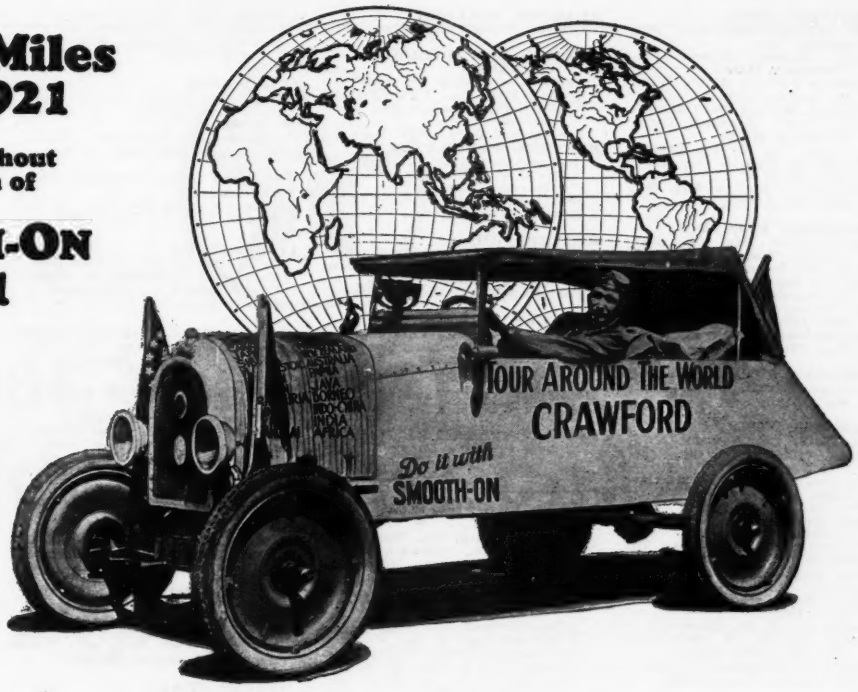

M. H. Crawford of Los Angeles in his motor car "Honolulu"

"CONTINUOUS Tourist" Crawford, as he is described in the New York Times, has been at it in this flivver since 1921—in Siberia, China, Indo-China, India, Africa and Australia—and has found Smooth-On No. 1 indispensable for emergency repairs. Mr. Crawford says that in rattling over ice in Siberia, and elsewhere on rough stretches without roads, Smooth-On No. 1 was the only thing that would keep the nuts and grease cups tight. Time and again he has stopped radiator leaks with Smooth-On, and in a wilderness in Indo-China, when the circulating pump broke, a repair contraption made from string and Smooth-On No. 1 enabled him to get his car back to civilization.

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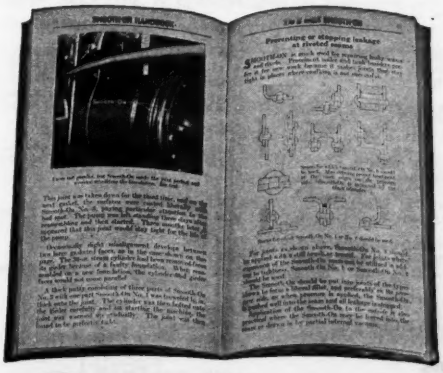

Where leaks at joints and cracks must be stopped, or new threaded or gasketed joints must be made tight, Smooth-On No. 1 offers the sure, quick and cheap method. A small supply kept on hand in the store room or repair kit usually repays its cost many times over on the first application.

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Fairbanks, Morse & Co., Chicago.
Moore Steam Turbine Corp., Wellsville, N. Y.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GENERATORS, ELECTRIC
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Elliott Co., Jeannette, Pa.
Engberg's Elec. & Mech. Wks., St. Joseph, Mich.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GOVERNORS, ENGINE
Pickering Governor Co., Portland, Conn.

GOVERNORS, PUMP
Atlas Valve Co., Newark, N. J.
Chapin-Fulton Mfg. Co., The, Pittsburgh.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Gardner-Denver Co., Quincy, Ill.
Illinois Engrg. Co., Chicago.
Mason Regulator Co., Boston.
Northern Equip. Co., Erie, Pa.
Pickering Governor Co., Portland, Conn.
Squires Co., C. E., Cleveland.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit.

GOVERNORS, STEAM ENGINE
Gardner-Denver Co., Quincy, Ill.

GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

GRATE BARS
Erie City Iron Wks., Erie.
Flynn & Emrich Co., Baltimore.

GRATES
Babcock & Wilcox Co., N. Y.
Flynn & Emrich Co., Baltimore.
Kelly Foundry & Mach. Co., Goshen, Ind.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Murray Iron Works Co., Burlington, Iowa.
Neemes Fdry., Inc., Troy, N. Y.

GRATES, DUMPING
Mc Clave-Brooks Co., Scranton.

GRATES, SHAKING
Mc Clave-Brooks Co., Scranton.

GRATES, STATIONARY
Mc Clave-Brooks Co., Scranton.

GRATING, STEEL
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

GRATING, VENTILATION
Blaw-Knox Co., Pittsburgh, Pa.
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

GREASE
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Phila.
Shell Petroleum Corp., St. Louis, Mo.
Standard Oil Co. (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Vacuum Oil Co., New York.

GREASE CUPS
(See Oil and Grease Cups.)

GUNS, REFRACTORY
Cement-Gun Co., Inc., Allentown, Pa.

HEAT EXCHANGERS
Foster Wheeler Corp, New York.
Griscom-Russell Co., New York.
National Pipe Bending Co., New Haven, Conn.
Prat-Daniel Corp., New York.
Superheater Co., New York.
Vogt Machine Co., Inc., Henry, Louisville, Ky.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.
Wheeler Mfg. Co., C. H., Phila.

HEATERS, AIR
Gradon Mfg. Co., Philadelphia.

HEATERS, BLEEDER
Griscom-Russell Co., New York.

HEATERS FOR SPECIAL PURPOSES
Combustion Engrg. Corp., N. Y.
Gradon Mfg. Co., Philadelphia.
National Pipe Bending Co., New Haven, Conn.
Prat-Daniel Corp., New York.

HEATERS, HOT WATER
Griscom-Russell Co., New York.
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley Co., New York.
Powers Regulator Co., Chicago.

HEATERS, OIL
Gradon Mfg. Co., Philadelphia.
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley Co., New York.

HEATERS, STORAGE
Gradon Mfg. Co., Philadelphia.
National Pipe Bending Co., New Haven, Conn.
Patterson-Kelley Co., New York.

HEATING SYSTEMS
Warren Webster & Co., Camden.

HIGH TEMPERATURE DRYING
Nichols Products Corp., N. Y.

HOISTS
Sullivan Machinery Co., Chicago.

HOISTS, SKIP
Beaumont Co., R. H., Phila.
Fairfield Engrg. Co., Marion, O.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.

HOPPERS AND BINS, COAL AND ASH
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Combustion Engrg. Corp., N. Y.
Connery & Co., Inc., Phila.
Frederick Iron & Steel Co., Frederick, Md.

HOSE
Crandall Pkg. Co., Palmyra, N. Y.
Quaker City Rubber Co., Phila.

Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.

LUBRICANTS
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Phila.
Shell Petroleum Corp., St. Louis, Mo.
Standard Oil Co. (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Vacuum Oil Co., New York.

LUBRICATORS
Greene, Tweed & Co., New York.
Keystone Lubricating Co., Phila.
Lunkenheimer Co., Cincinnati.
Manzel Bros. Co., Buffalo, N. Y.

LUBRICATORS, FORCED FEED
Greene, Tweed & Co., New York.
Manzel Bros. Co., Buffalo, N. Y.

MECHANICAL DRAFT APPARATUS
Buffalo Forge Co., Buffalo.
Coppus Engrg. Corp., Worcester.
Prat-Daniel Corp., New York.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

METERS, AIR AND GAS
Bailey Meter Co., Cleveland, O.
Republic Flow Meters Co., Chicago.

METERS, BOILER
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.
Yarnall-Waring Co., Phila.

METERS, COAL
Bailey Meter Co., Cleveland, O.
C-J Mfg. Co., Philadelphia.
Republic Flow Meters Co., Chicago.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 170

HUMIDIFIERS
Nichols Products Corp., N. Y.

ICE MAKING AND REFRIGERATING MACHINERY
Vogt Machine Co., Inc., Henry, Louisville, Ky.

INDICATORS, ENGINE
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.

INJECTORS AND INSPIRATORS
Penberthy Injector Co., Detroit.
Schutte & Koerting Co., Phila.
Superheater Co., The, New York.

INSTRUMENTS, ELECTRICAL
Weston Elec. Inst. Corp., Newark.

INSTRUMENTS, RECORDING
Weston Elec. Inst. Corp., Newark.

INSULATING MATERIAL
Banner Rock Products Co., Alexandria, Ind.
Johns-Manville Corp, New York.
Quigley Furnace Spec. Co., N.Y.

JOINTS EXPANSION
American District Steam Co., N. Tonawanda, N. Y.
Foster Wheeler Corp., New York.
Gradon Mfg. Co., Philadelphia.
Howard Iron Works, Buffalo.
Kellogg Co., The M. W., N. Y.
Wheeler Mfg. Co., C. H., Phila.

LADDER STEPS, STEEL
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

LINING, FURNACE
Lavino and Co., E. J., Phila., Pa.
Norton Co., Worcester, Mass.

LININGS, COAL BUNKER
Walles Dove-Hermiston Corp., New York, N. Y.

LOADERS AND UNLOADERS
Fairfield Engrg. Co., Marion, O.

METERS, FEED WATER
Bailey Meter Co., Cleveland, O.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.
Worthington Pump & Mach. Corp., New York.

METERS, STEAM
American Dist. Steam Co., No. Tonawanda, N. Y.
Bailey Meter Co., Cleveland, O.
Republic Flow Meters Co., Chicago.

METERS, WATER
Bailey Meter Co., Cleveland, O.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.

MOND "SEVENTY" METAL
American Mond Nickel Co., Pittsburgh.

NOZZLES FOR ALL PURPOSES
Binks Spray Equip. Co., Chicago.
Schutte & Koerting Co., Phila.

OIL AND GREASE CUPS
Keystone Lubricating Co., Phila.
Lonergan Co., J. E., Phila., Pa.
Lunkenheimer Co., Cincinnati.
Penberthy Injector Co., Detroit.

OIL BURNING EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Peabody Engrg. Corp., N. Y.
Schutte & Koerting Co., Phila.

OIL, COAL, GAS BURNER
Peabody Engrg. Corp., N. Y.

OIL PURIFIERS
De Laval Steam Turbine Co., Trenton, N. J.

OIL SEPARATORS
Elliott Co., Jeannette, Pa.
Wright-Austin Co., Detroit.

OIL TANKS
Manzel Bros. Co., Buffalo, N. Y.

OILING SYSTEMS
Burt Mfg. Co., The, Akron, O.

OILS, LUBRICATING
Dearborn Chemical Co., Chicago.
Shell Petroleum Corp., St. Louis, Mo.
Standard Oil Co. (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Vacuum Oil Co., New York.

PACKING, ASBESTOS
Belmont Pkg. & Rubber Co., Philadelphia.
Crandall Pkg. Co., Palmyra, N.Y.
Garlock Pkg. Co., Palmyra, N.Y.
Ric-wil Co., Cleveland, Ohio.

PACKING, CENTRIFUGAL PUMP
Alfit Mfg. Co., Inc., New York.
Allpax Co., Inc., The, Mamaroneck, N. Y.
Belmont Pkg. & Rubber Co., Philadelphia.
Conneaut Pkg. Co., Conneaut, O.
Garlock Pkg. Co., Palmyra, N. Y.
Metalastic Inc., Jersey City, N. J.

PACKING, FLAX
Belmont Pkg. & Rubber Co., Philadelphia.
Crandall Pkg. Co., Palmyra, N.Y.
Garlock Pkg. Co., Palmyra, N. Y.

PACKING, METALLIC
Alfit Mfg. Co., Inc., New York.
American Metallic Packing Co., Pittsburgh, Pa.
Belmont Pkg. & Rubber Co., Philadelphia.
Conneaut Pkg. Co., Conneaut, O.
Crandall Pkg. Co., Palmyra, N. Y.
Crane Packing Co., Chicago, Ill.
Garlock Pkg. Co., Palmyra, N. Y.
Holmes Metallic Packing Co., Wilkes-Barre, Pa.
Metalastic Inc., Jersey City, N. J.

PACKING, METALLIC FOR CONDENSER TUBES
Allpax Co., Inc., The, Mamaroneck, N. Y.
Crane Packing Co., Chicago, Ill.

PACKING, PISTON AND ROD
Alfit Mfg. Co., Inc., New York.
Allpax Co., Inc., The, Mamaroneck, N. Y.
Belmont Pkg. & Rubber Co., Philadelphia.
Conneaut Pkg. Co., Conneaut, O.
Crandall Pkg. Co., Palmyra, N.Y.
Crane Packing Co., Chicago, Ill.
Garlock Pkg. Co., Palmyra, N. Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Greene, Tweed & Co., N. Y.
Johns-Manville Corp., New York.
Metalastic Inc., Jersey City, N. J.
Quaker City Rubber Co., Phila.

PACKING, SHEET
Belmont Pkg. & Rubber Co., Philadelphia.
Colt's Patent Fire Arms Mfg. Co., Hartford, Conn.
Crandall Pkg. Co., Palmyra, N.Y.
Garlock Pkg. Co., Palmyra, N.Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.
Johns-Manville Corp., New York.
Quaker City Rubber Co., Phila.

PACKING, VALVE STEM
Alfit Mfg. Co., Inc., New York.
Allpax Co., Inc., The, Mamaroneck, N. Y.
Belmont Pkg. & Rubber Co., Philadelphia.
Conneaut Pkg. Co., Conneaut, O.
Garlock Pkg. Co., Palmyra, N.Y.
Johns-Manville Corp., New York.
Metalastic Inc., Jersey City, N. J.
Quaker City Rubber Co., Phila.

PAINT, ANTI-CORROSIVE
Dampney Co. of Am., Boston.
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, FLOOR
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

PAINT, HEAT RESISTING
Dampney Co. of Am., Boston.
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, METAL
Dampney Co. of Am., Boston.

PAINT, PROTECTIVE
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, STEEL PRESERVATIVE
Dampney Co. of Am., Boston.

What Should You Pay for Lubrication?

It all Depends—

1— How much protection to machine and equipment do you want? (All you can buy.)

2— How high are you willing to let expenses for repairs run? In other words, how often are you willing to bear the cost of idle machinery due to repairs and replacements brought about by ineffective lubrication? (Never, if you can help it!)

3— What degree of efficiency do you expect from your equipment? (The maximum, certainly.)

These are matters that have a direct bearing on the cost for lubrication.

We know lubricants and we know the problems that may be encountered in their application.

We know that varying degrees of efficiency may be expected from each kind and type of lubricant.

And we agree, that YOU, the buyer, must consider price in figuring costs. But we ask you, for your own good: Never consider price first but always last. Because only in the end—after the lubricant has had a chance to do its work—can you tell what lubrication costs.

That is the only way to judge—by results of lubrication.

Judged by results, TEXACO lubricants are the cheapest lubricants you can buy.

They will save power by their ability to reduce friction.

They will protect your equipment against wear, thus saving on the cost for repairs and replacements.

Because of the results obtainable—what they save—not what they cost—TEXACO LUBRICANTS are being used in more and more power plants, shops, mines and mills throughout the country, on every conceivable kind of equipment.

It will put you under no obligation whatever to have a well equipped TEXACO Engineer inspect your property. He will tell from experience which TEXACO Lubricant is best to use and tell you just what, where and how you can save on lubrication.

There Is a Texaco Lubricant for Every Purpose

THE TEXAS COMPANY

Texaco Petroleum Products

DEPT. QD, 17 BATTERY PLACE, NEW YORK CITY

OFFICES IN PRINCIPAL CITIES

PIPE BENDING
Grinnell Co., Inc., Providence.
National Pipe Bending Co., New Haven, Conn.
National Valve & Mfg. Co., Pittsburgh.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.
Walworth Co., Boston.

PIPE CLAMPS, COUPLINGS AND JOINTS
Grinnell Co., Inc., Providence.

PIPE COILS
Grinnell Co., Inc., Providence.
National Pipe Bending Co., New Haven, Conn.
Power Piping Co., Pittsburgh.
Superheater Co., The, New York.
Vogt Machine Co., Inc., Henry, Louisville, Ky.

PIPE COVERINGS
American Dist. Steam Co., No. Tonawanda, N. Y.
Banner Rock Products Co., Alexandria, Ind.
Johns-Manville Corp., New York.
Ric-Wil Co., Cleveland.

PIPE CUTTERS
Toledo Pipe Threading Mach. Co., The, Toledo, O.
Walworth Co., Boston.

PIPE FABRICATORS
Grinnell Co., Inc., Providence.
Power Piping Co., Pittsburgh.

PIPE HANGERS & SUPPLIES
Grinnell Co., Inc., Providence.

PIPE SAVERS
Pipe Saver Corp. of America, Carthage, N. Y.

PIPE THREADING MACHINES
Toledo Pipe Threading Mach. Co., The, Toledo, O.

PIPE, WROUGHT STEEL
National Tube Co., Pittsburgh.

PIPING
Baker Co., Inc., R. H., Cambridge, Mass.
Connery & Co., Inc., Phila.
Kellogg Co., The M. W., N. Y.
National Tube Co., Pittsburgh.
National Valve & Mfg. Co., Pittsburgh.
Power Piping Co., Pittsburgh.
Walworth Co., Boston.

PIPING CONTRACTING MANUFACTURERS
Baker Co., Inc., R. H., Cambridge, Mass.
Grinnell Co., Inc., Providence.
Kellogg Co., The M. W., N. Y.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Power Piping Co., Pittsburgh.
Pope, Wm. A., Chicago.

PORTABLE CONVEYORS
Jeffrey Mfg. Co., Columbus, O.

POWER PLANT MANAGEMENT
Stone & Webster, Inc., Boston.

POWER SHOWS
Midwestern Engrg. Exposition, Inc., Chicago, Ill.

PREHEATER AND HEAT EXCHANGERS
Gradon Mfg. Co., Philadelphia.
Patterson-Kelley Co., New York.
Prat-Daniel Corp., New York.

PROTECTIVE COATINGS
Dampney Co. of Am., Boston.

PULVERIZED FUEL EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Erie City Iron Wks., Erie.
Foster Wheeler Corp., N. Y.
Fuller Lehigh Co., Fullerton, Pa.
Riley Stoker Corp., Worcester.

PULVERIZERS, COAL
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., The, Columbus.
Pennsylvania Crusher Co., Phila.
Riley Stoker Corp., Worcester, Mass.
Strong-Scott Mfg. Co., Minneapolis, Minn.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.

PUMPING SYSTEMS, AIR LIFT
Sullivan Machinery Co., Chicago.

PUMPS
Murray Iron Works Co., Burlington, Iowa.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, BOILER FEED
Bethlehem Steel Co., Bethlehem.
Buffalo Steam Pump Co., Buffalo, N. Y.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., Chicago.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Gardner-Denver Co., Quincy, Ill.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Machy. Corp., New York.

PUMPS, CENTRIFUGAL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., Chicago.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Kingsford Fdry. & Mach Wks., Oswego, N. Y.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Nash Engrg. Co., South Norwalk, Conn.
Northern Equipment Co., Erie.
Platt Iron Works, Dayton, O.
Terry Steam Turbine Co., Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp, New York.

PUMPS, DEEP WELL
Fairbanks, Morse & Co., Chicago.
Northern Equipment Co., Erie.
Platt Iron Works, Dayton, O.
Westco - Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Mach. Corp., New York.

PUMPS, ELECTRIC
Gardner-Denver Co., Quincy, Ill.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, ELEVATOR AND FIRE
De Laval Steam Turbine Co., Trenton, N. J.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, GENERAL SERVICE
Bethlehem Steel Co., Bethlehem.
Buffalo Steam Pump Co., Buffalo, N. Y.
Nash Engrg. Co., South Norwalk, Conn.
Platt Iron Wks., Dayton, O.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, HYDRAULIC PRESSURE
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.

PUMPS, JET
Manistee Iron Works, Manistee.

PUMPS, OIL
Gardner-Denver Co., Quincy, Ill.
Lonergan Co., J. E., Phila., Pa.
Lunkenheimer Co., Cincinnati.
Manzel Bros. Co., Buffalo, N. Y.
Penberthy Injector Co., Detroit.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, POWER
Fairbanks, Morse & Co., Chicago.
Gardner-Denver Co., Quincy, Ill.
Lecourtenay Co., Newark, N. J.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mas.
Westco-Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Mach. Corp., New York.

PUMPS, ROTARY
Manistee Iron Works, Manistee.
Platt Iron Works, Dayton, O.
Wheeler Mfg. Co., C. H., Phila.

PUMPS, STEAM
Platt Iron Works, Dayton, O.
Titusville Iron Works Co., Titusville, Pa.

PUMPS, TURBINE
Moore Steam Turbine Corp., Wellsville, N. Y.

PUMPS, VACUUM
Allen & Billmyre Co., Inc., N. Y.
Chicago Pneumatic Tool Co., New York, N. Y.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Gardner-Denver Co., Quincy, Ill.
Manistee Iron Works, Manistee.
Nash Engrg. Co., South Norwalk, Conn.
Sullivan Machy. Co., Chicago.
Warren Steam Pump Co., Inc., Warren, Mass.
Wheeler Mfg. Co., C. H., Phila.

PUMPS, WATERWORKS
Allis-Chalmers Co., Milwaukee.
Bethlehem Steel Co., Bethlehem.
Fairbanks, Morse & Co., Chicago.
Gardner-Denver Co., Quincy, Ill.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Platt Iron Works, Dayton, O.
Terry Steam Turbine Co., Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 170

PURIFIERS, BOILER FEED
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Sims Co., The, Erie, Pa.

PURIFIERS, STEAM
Hagan Corp., Pittsburgh, Pa.

PYROMETERS
Bristol Co., The, Waterbury.
Republic Flow Meters Co., Chicago, Ill.
Superheater Co., The, N. Y.

QUENCHERS, ASH
Allen-Sherman-Hoff Co., The Philadelphia, Pa.

RECORDERS, LIQUID LEVEL
Bristol Co., The, Waterbury.

RECORDING INSTRUMENTS
Bristol Co., The, Waterbury.

REFRACTORIES
Faulkner Refractories Co., J. A., Youngstown, Ohio.
Harbison-Walker Refract. Co., Pittsburgh.
King Refrac. Co., Inc., Buffalo.
Lavino and Co., E. J., Phila.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Quigley Furnace Spec. Co., N. Y.
Rust Engrg. Co., Pittsburgh.

REGULATORS, DAMPER
Atlas Valve Co., Newark, N. J.
d'Este Co., Julian, Boston, Mass.
Hagan Corp., Pittsburgh, Pa.
Mason Regulator Co., Boston.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Wing Mfg. Co., L. J., New York.

REGULATORS, FAN ENGINE
Atlas Valve Co., Newark, N. J.

REGULATORS, FEED WATER
Atlas Valve Co., Newark, N. J.
Chaplin-Fulton Mfg. Co., Pittsburgh.
Northern Equipment Co., Erie.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York.
Squires Co., C. E., Cleveland.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.
Wright-Austin Co., Detroit.

REGULATORS, PRESSURE
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Hagan Corp., Pittsburgh, Pa.
Illinois Engrg. Co., Chicago.
Mason Regulator Co., Chicago.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.
Squires Co., C. E., Cleveland.
Strong Carlisle & Hammond Co., Cleveland, Ohio.
Watson & McDaniel Co., Phila.

REGULATORS, TEMPERATURE
Atlas Valve Co., Newark, N. J.
Bristol Co., The, Waterbury.
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.
d'Este Co., Julian, Boston, Mass.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.

ROPE, WIRE
American Steel & Wire Co., Chicago and New York.

RUST PREVENTIVES
Dearborn Chem. Co., Chicago.

SCALE REMOVERS (Mechanical)
General Specialty Co., Buffalo.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

SCRAPERS, CABLE DRAG
Beaumont Co., R. H., Phila.

SCREENS
Stephens - Adamson Mfg. Co., Aurora, Ill.

SEAL RINGS
Cooke Seal Ring Co., Chicago, Ill.

SEPARATORS AND EXTRACTORS, STEAM AND OIL
Blaw-Knox Co., Pittsburgh, Pa.
Cochrane Corp., Philadelphia.
d'Este Co., Julian, Boston, Mass.
Direct Separator Co., Syracuse.
Gardner-Denver Co., Quincy, Ill.
Gradon Mfg. Co., Philadelphia.
Hagan Corp., Pittsburgh, Pa.
Hoppes Mfg. Co., Springfield, O.
Illinois Engrg. Co., Chicago.
Kellogg Co., The M. W., N. Y.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Sims Co., The, Erie, Pa.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Swartwout Co., Cleveland.
Wright-Austin Co., Detroit.

SEPARATORS, STEAM AND AIR
Barrett Machine Co., Pittsburgh.
Hagan Corp., Pittsburgh, Pa.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

SHAFTING
National Tube Co., Pittsburgh.

SLUICING SYSTEMS, ASH
Allen-Sherman-Hoff Co., Phila.

SODIUM ALUMINATE
National Aluminate Corp., Chicago, Ill.

SOOT BLOWERS
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
National Flue Cleaner Co., Inc., Groveville, N. J.
Vulcan Soot Cleaner Co., Dubois, Pa.

SPRAY AIR WASHERS
Binks Spray Equip. Co., Chicago

SPRAY BOOTHS
Nichols Products Corp., N. Y.

SPRAY COOLING SYSTEMS
Binks Spray Equip. Co., Chicago.
Buffalo Forge Co., Buffalo.
Marley Co., The, Kansas City, Mo.
Yarnall-Waring Co., Phila.

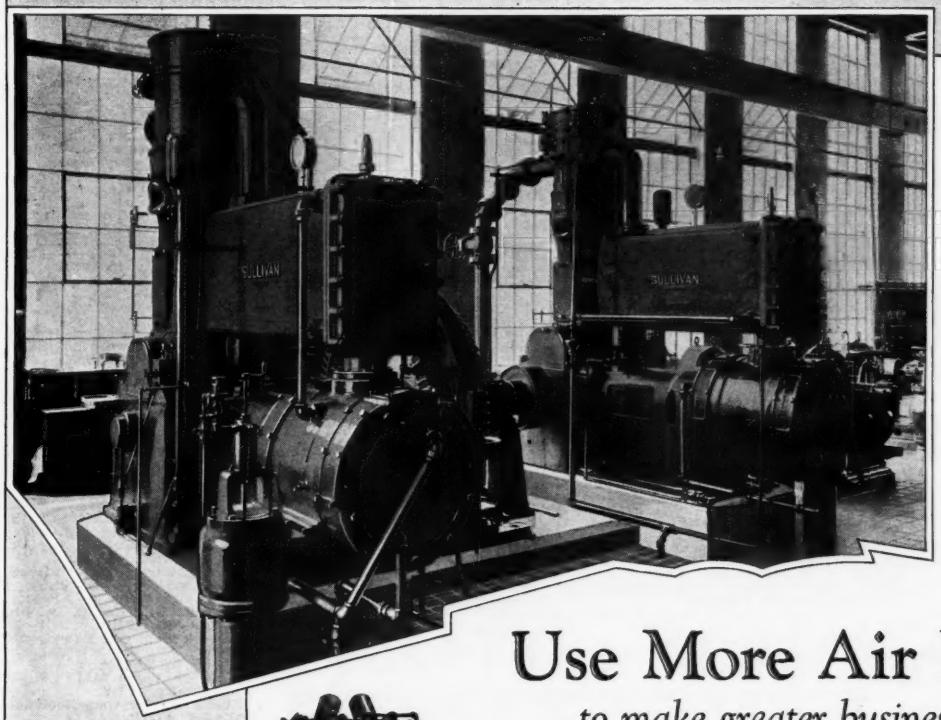
SPRAY NOZZLES
Yarnall-Waring Co., Phila.

SPROCKET RIMS
Babbitt Steam Specialty Co., New Bedford, Mass.

STACKS, METAL
Connery & Co., Inc., Phila.
Erie City Iron Wks., Erie.
Prat-Daniel Corp., New York.
Vogt Machine Co., Inc., Henry, Louisville, Ky.

STAIR TREAD, ANTI-SLIP
Blaw-Knox Co., Pittsburgh, Pa.

DEPEND ON SULLIVAN AIR POWER



A Sullivan Twin-Angle Compound Air Compressor in a plant of the General Motors Corporation

Use More Air Power--

to make greater business in 1929 mean larger profits

THE business outlook for 1929 is good. New machinery, and new manufactured products of all kinds—will be wanted.

Greater business will mean larger profits for many factories. They will increase the productivity of labor with air power.

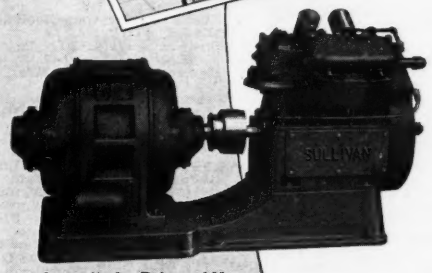
Air power supplied by modern Sullivan Compressors is cheap. And there is a compressor of size, type, and drive, exactly suited to your needs.

Angle Compound Compressors, single-stage horizontal, and single-stage vertical machines of many sizes give you a range of capacities from 68 to 5100 cu. ft. per minute; with drive by belt or direct connection to motor or oil engine.

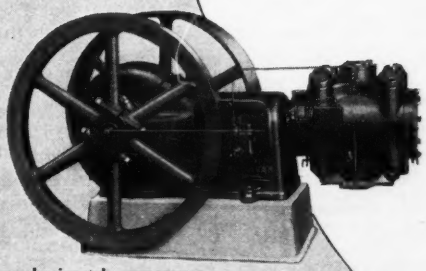
Investigate the advantages of compressed air in your plant. A Sullivan Air Power Engineer will help you plan for 1929—to make greater business mean larger profits.

Catalogs on Request

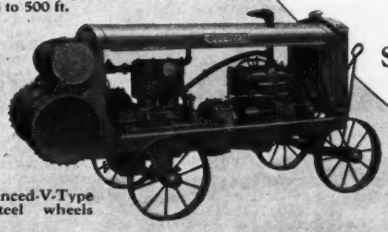
SULLIVAN MACHINERY COMPANY
301 People's Gas Bldg., Chicago, Ill.



240-ft. 4-cylinder Balanced-V-Type Compressor



Belt-driven horizontal compressor, capacities 68 to 500 ft.



310-ft. Portable Balanced-V-Type compressor on steel wheels

SULLIVAN TRADE MARK

Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

STEAM GENERATING EQUIPMENT
Combustion Engrg. Corp., N. Y.

STEAM PURIFIERS
Blaw-Knox Co., Pittsburgh, Pa.

STEAM TRAPS
American Dist. Steam Co., No. Tonawanda, N. Y.
Armstrong Machine Wks., Three Rivers, Mich.
Bundy Steam Trap Co., Nashua.
Cochrane Corp., Philadelphia.
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Johns-Manville Corp., New York.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Patterson-Kelley Co., New York.
Powers Regulator Co., Chicago.
Reliance Gauge Column Co., Cleveland.
Sarco Company, Inc., New York.
Squires Co., C. E., Cleveland.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Swartwout Co., Cleveland.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit.
Yarnall-Waring Co., Phila.

STEAM TURBINES—POWER
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Carling Turbine Blower Co., Worcester, Mass.
DeLaval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannete, Pa.
Moore Steam Turbine Co., Wellsville, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wing Mfg. Co., L. J., New York.

STOCKS AND DIES
Toledo Pipe Threading Mach. Co., The, Toledo, O.

STOKERS, CHAIN AND TRAVELING GRATE
Mc Clave-Brooks Co., Scranton.

STOKERS, CHAIN GRATE
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Laclede Stoker Co., St. Louis.
Riley Stoker Corp., Worcester.

STOKERS, FORCED DRAFT
Mc Clave-Brooks Co., Scranton.

STOKERS, HAND OPERATED
Flynn & Emrich Co., Baltimore.
Kelly Foundry & Mach. Co., The, Goshen, Ind.
Marion Mach. Fdry. & Supply Co., Marion, Ind.

STOKERS, MECHANICAL
American Engrg. Co., Phila.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
Mc Clave-Brooks Co., Scranton.
Riley Stoker Corp., Worcester.

STOKERS, OVERFEED
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
Laclede Stoker Co., St. Louis.
Riley Stoker Corp., Worcester.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

STOKERS, UNDERFEED
American Engrg. Co., Phila.
Combustion Engrg. Corp., N. Y.
Detroit Stoker Co., Detroit.
Riley Stoker Corp., Worcester.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

STRAINERS
Davis Regulator Co., G. M., Chicago.
Sarco Co., Inc., New York.
Wright-Austin Co., Detroit.

STRAINERS, OIL
Sarco Co., Inc., New York.

SUPERHEATERS, STEAM
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Foster Wheeler Corp., N. Y.
Marley Co., The, Kansas City, Mo.
Superheater Co., The, New York.

SWITCHBOARDS, ASBESTOS
Johns-Manville Corp., New York.

TACHOMETERS
Bristol Co., The, Waterbury.
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.

TANKS
Connery & Co., Inc., Phila.
Erie City Iron Wks., Erie.
Hedges - Walsh - Weidner Co., New York, N. Y.
Kellogg Co., The M. W., N. Y.
Murray Iron Works Co., Burlington, Iowa.
Sims Co., The, Erie, Pa.
Springfield Boiler Co., Springfield, Ill.
Titusville Iron Works Co., Titusville, Pa.
Vogt Machine Co., Inc., Henry, Louisville, Ky.

THERMOMETERS
Bristol Co., The, Waterbury.
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.
Powers Regulator Co., Chicago.

THERMOMETERS, RECORDING AND INDICATING
Bristol Co., The, Waterbury.
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.

TOOLS AND SUPPLIES
Pilley Packing & Flue Brush Mfg. Co., St. Louis, Mo.

TRAMWAYS
American Steel & Wire Co., Chicago and New York.

TRAPS, COMPRESSED AIR
Armstrong Machine Wks., Three Rivers, Mich.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

TRAPS, RADIATOR
Armstrong Machine Wks., Three Rivers, Mich.
Sarco Co., Inc., New York.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Warren Webster & Co., Camden.

TRAPS, RETURN
Bundy Steam Trap Co., Nashua.
d'Este Co., Julian, Boston, Mass.
Sarco Co., Inc., New York.
Warren Webster & Co., Camden.

TRAPS, STEAM AND RADIATOR
Illinois Engrg. Co., Chicago.
Sarco Co., Inc., New York.
Warren Webster & Co., Camden.

TRAPS, VACUUM
Armstrong Machine Wks., Three Rivers, Mich.
Bundy Steam Trap Co., Nashua.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Warren Webster & Co., Camden.

TRAVELING CRANES
Wellman - Seaver - Morgan Co., The, Cleveland, O.

TUBE COATINGS
Dampney Co. of Am., Boston.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 170

TUBE CUTTERS
Lagonda Mfg. Co., Springfield, O.

TUBING
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
National Tube Co., Pittsburgh.

TUBING CONDENSER
Foster Wheeler Corp., N. Y.

TUBING, SEAMLESS STEEL
National Tube Co., Pittsburgh.

TURBINES, HYDRAULIC
DeLaval Steam Turbine Co., Trenton, N. J.

TURBINES, STEAM
Murray Iron Works Co., Burlington, Iowa.

TURBO GENERATORS
Elliott Co., Jeannette, Pa.
Murray Iron Works Co., Burlington, Iowa.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

UNDERGROUND HEATING SYSTEM
American Dist. Steam Co., No. Tonawanda, N. Y.
Baker Co., Inc., R. H., Cambridge, Mass.
Johns-Manville Corp., N. Y.
Ric-Wil Co., Cleveland.

UNIONS
Atlas Valve Co., Newark, N. J.
Central Forging Co., Catawissa, Pa.
Dart Mfg. Co., E. M., Providence, R. I.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Walworth Co., Boston.

VACUUM CLEANING SYSTEMS
Allen & Billmyre Co., Inc., N. Y.

VALVE DISCS
Garlock Pkg. Co., Palmyra, N.Y.
Goetze Gasket & Packing Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.
Metallo Gasket Co., New Brunswick, N. J.

VALVES
Atlas Valve Co., Newark, N. J.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Northern Pump Co., Minneapolis, Minn.
Vogt Machine Co., Inc., Henry, Louisville, Ky.

VALVES, AUTOMATIC CUT-OFF
Elliott Co., Jeannette, Pa.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.

VALVES, AUTOMATIC STOP AND CHECK
Davis Regulator Co., G. M., Chicago, Ill.
Illinois Engrg. Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.

VALVES, BLOW-OFF
Barrett Machine Co., Pittsburgh.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Everlasting Valve Co., Jersey City, N. J.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Jenkins Bros., New York, N. Y.
Lunkenheimer Co., Cincinnati, O.
Yarnall-Waring Co., Phila.

VALVES, BY-PASS
Jenkins Bros., New York, N. Y.
Mason Regulator Co., Boston.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.

VALVES, CHECK
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The Elmira, N. Y.
Lunkenheimer Co., Cincinnati, O.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Schutte & Koerting Co., Phila.
Walworth Co., Boston.

VALVES, FLOAT
Atlas Valve Co., Newark, N. J.
Davis Regulator Co., G. M., Chicago, Ill.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Mason Regulator Co., Boston.

VALVES, GATE
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Lunkenheimer Co., Cincinnati.
National Valve & Mfg. Co., Pittsburgh, Pa.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Vogt Machine Co., Inc., Henry, Louisville, Ky.
Walworth Co., Boston.

VALVES, GLOBE
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Lunkenheimer Co., Cincinnati.
Pittsburgh Valve, Fdry. & Construction Co., Pittsburgh.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Walworth Co., Boston.

VALVES, HYDRAULIC
Barrett Machine Co., Pittsburgh.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Yarnall-Waring Co., Phila.

VALVES, NON-RETURN
Davis Regulator Co., G. M., Chicago, Ill.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Illinois Engrg. Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Schutte & Koerting Co., Phila.
Strong, Carlisle & Hammond, Co., Cleveland, Ohio.

VALVES, POP SAFETY
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.
Lonergan Co., J. E., Phila., Pa.
Lunkenheimer Co., Cincinnati.

VALVES, PUMP
Colt's Patent Fire Arms Mfg. Co., Hartford, Conn.
Crandall Pkg. Co., Palmyra, N.Y.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Garlock Pkg. Co., Palmyra, N.Y.
Jenkins Bros., New York, N. Y.
Quaker City Rubber Co., Phila.

VALVES, RADIATOR
American Dist. Steam Co., No. Tonawanda, N. Y.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Sarco Co., Inc., New York.

VALVES, REDUCING
Atlas Valve Co., Newark, N. J.
Chapin-Fulton Mfg. Co., Pittsburgh, Pa.
Insley 10-29 M-4 5½pt 10ms
Davis Regulator Co., G. M., Chicago, Ill.
d'Este Co., Julian, Boston, Mass.
Elliott Company, Jeannette, Pa.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Mason Regulator Co., Boston.
Powers Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Squires Co., C. E., Cleveland, O.
Watson & McDaniel Co., Phila.

VALVES, REGRINDING
Homestead Valve Mfg. Co., Coraopolis, Pa.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Mason Regulator Co., Boston.
Penberthy Injector Co., Detroit.

VALVES, REGULATING
Atlas Valve Co., Newark, N. J.
Davis Regulator Co., G. M., Chicago.
Powers Regulator Co., Chicago.
Swartwout Co., Cleveland.

VALVES, RELIEF
Cochrane Corp., Philadelphia.
Consolidated Ashcroft Hancock Co., Inc., Brooklyn, N. Y.
Davis Regulator Co., G. M., Chicago.
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Fisher Governor Co., Inc., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Lonergan Co., J. E., Phila., Pa.
Mason Regulator Co., Boston.
Wheeler Mfg. Co., C. H., Phila.

VALVES, RUBBER
Garlock Pkg. Co., Palmyra, N.Y.
Quaker City Rubber Co., Phila.

VALVES, STEEL
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Lunkenheimer Co., Cincinnati.

VALVES, STOP
Edward Valve & Mfg. Co., The, East Chicago, Ind.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Schutte & Koerting Co., Phila.

VALVES, THREE AND FOUR WAY
Nicholson & Co., W. H., Wilkes-Barre, Pa.

VENTILATING APPARATUS
Buffalo Forge Co., Buffalo.
Burt Mfg. Co., The, Akron, O.
Coppus Engrg. Corp., Worcester.
Sturtevant Co., B. F., Boston.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.

WALKWAYS, OPEN STEEL
Blaw-Knox Co., Pittsburgh, Pa.
Irving Iron Works Co., Long Island City, N. Y.
Kerlow Steel Flooring Co., Jersey City, N. J.

WATER BACKS, HIGH AND LOW PRESSURE
Mc Clave-Brooks Co., Scranton.

WATER COLUMNS AND ALARMS
Reliance Gauge Column Co., The, Cleveland, O.
Wright-Austin Co., Detroit.
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WATER COOL FURNACE SURFACE
Foster Wheeler Corp., N. Y.
Hedges - Walsh - Weidner Co., New York, N. Y.

WATER COOLING EQUIPMENT
Marley Co., The, Kansas City, Mo.

WATER SOFTENING SYSTEMS
Cochrane Corp., Philadelphia.
Dearborn Chemical Co., Chicago.
Griscom-Russell Co., New York.
National Aluminate Corp., Chicago, Ill.

WATER TESTING EQUIPMENT
National Aluminate Corp., Chicago, Ill.

WATER WALLS
Fuller Lehigh Co., Fullerton, Pa.

WEIGH LARRIES
Beaumont Co., R. H., Phila.
Stephens - Adamson Mfg. Co., Aurora, Ill.

WELDED HEADERS
Grinnell Co., Providence, R. I.

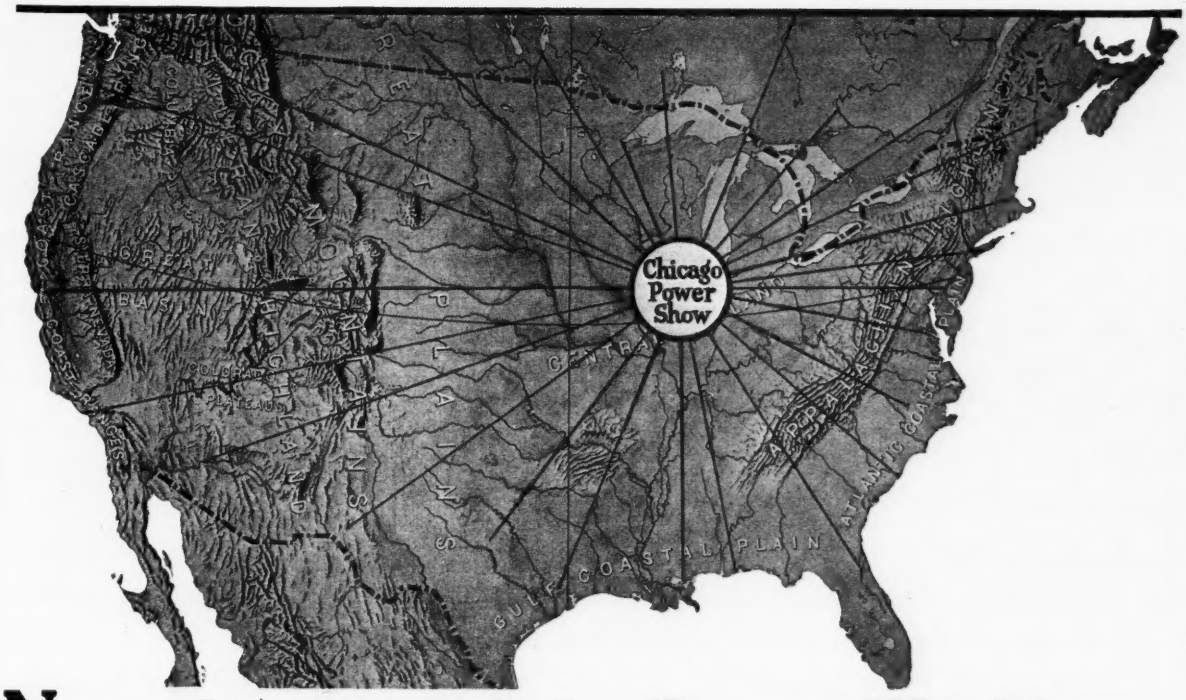
WHISTLES
Lonergan Co., J. E., Phila., Pa.

WIRE BRUSHES
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

WIRE OF EVERY DESCRIPTION
American Steel & Wire Co., Chicago and New York.

WIRE ROPE AND FITTINGS
American Steel & Wire Co., Chicago and New York.

WRENCHES
Walworth Co., Boston.



Now the eyes of the Power World Turn to the Midwest!

HERE the Fourth Midwestern Engineering and Power Exposition will spread before its visitors machinery and equipment that cost millions and great time and thought to develop. Many manufacturers will be represented with more than 500 items of the most advanced equipment on the market.

Thousands of miles of travel and much time would be necessary to study this machinery in the various places of manufacture and installation. All may be seen at this Exposition at small cost and by scarcely more than an overnight trip from the principal power centers of the great Middle West.

Analysis of attendance at previous Expositions shows that a large proportion of the visitors were engineers and executives responsible for the design, operation and maintenance of plants generating and utilizing power, representing the leading industries of the country such as utilities, iron, steel, railroads, petroleum, packing and manufacturing of all kinds.

It is to your advantage to take your place among such leaders of your profession and to capitalize on this opportunity for study and inspection without which an engineer cannot further his own interests and those of his plant or industry.

The Power Needs of 60 Million People

are served by industrial and public utility plants of the Middle West.
Meet the leaders in technical education, the consulting, designing and construction engineers, internationally known industrial and financial leaders, scientific men who specialize in the sciences that contribute to power efficiency, and the engineering representatives of manufacturing firms who have helped in the application of the latest equipment in hundreds of plants of all kinds.
Five great days in which to see exhibits showing every requisite for the modern power plant, with opportunities for associations and contacts with the men responsible for increasing power development are offered to the engineers of the country at this great centrally located Exposition.

MIDWESTERN ENGINEERING EXPOSITION, Inc.
53 W. JACKSON BLVD., CHICAGO

Meet with the Masters of Power at the

Chicago Power Show

Coliseum February 12 to 16 INC.

SIGNBOARD SECTION
Quick Action Opportunities

CLASSIFIED RATES

Advertisements in the Signboard Section which come under the classification "Position Wanted," "Help Wanted," "Salesmen and Agencies," "Business Opportunities," "Patents and Patent Attorneys" and "Technical Books" will be set in type as shown below and published at the rate of

50 cents a line

each insertion, 6 words to a line; minimum sold, 4 lines.

For display of any advertisement under the classified headings see sizes and rates in column at right.

DISPLAY RATES

Advertisements in Signboard Section which come under the classification "Equipment for Sale," "Equipment Wanted," "Educational and Instruction," and "Miscellaneous" are set in display space of the following sizes and at these rates:

1 in.	$ 5.50	4 in.	$20.80
2 in.	10.80	1 col. (8½ in.)	43.35
3 in.	15.90	2 col. (17 in.)	85.00

Not less than one inch to be sold in these classifications.

For advertising rates under other headings in this section, see column at left.

ENGINEERS WANTED

GOOD JOBS OPEN

Central stations must have meter experts. Hundreds of competent men wanted for positions paying $3,000 and over. We can train YOU at home in your spare time.

BE A METER ENGINEER

A postcard brings full details. No obligation.

FT. WAYNE CORRESPONDENCE SCHOOL

Dept. "P", Ft. Wayne, Ind.

MECHANICAL ENGINEER WANTED—by large New England industrial and power plant piping contractor. Applicants must have had previous experience in large piping installations and must be thoroughly familiar with mechanical equipment used in modern power plants and all material used in large piping installations. A man of good appearance and pleasing personality between the ages of 24 and 32 is desired, whose previous experience will enable him to handle intelligently all details relating to mechanical equipment for power plants. Salary to start $3,000.00 a year. To a man having these qualifications will be offered an attractive future with an established concern. Write, stating experience, age, references and when available. Address Box 964, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

BOILER FOREMAN for large copper company, South America. Applicant must be single and thoroughly experienced with high boiler pressure operations. Good living and working conditions, three years' contract, all traveling expenses paid. State fully experience, age and when available. Address "O. R.", Post Office Box 822, City Hall Station, New York City.

DESIGNING ENGINEER for rotary pump. Must have actual experience designing modern pumping equipment of the centrifugal or rotary type. To receive consideration, state fully and in typewriting complete experience and education, names of past and present employers, salary desired. Position offers good opportunity with small growing company in northern New Jersey. Employers will not be referred to until permission has been secured from applicant. All communications held in strict confidence. Box 960, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

POSITIONS WANTED

EXECUTIVE OR SALES. High Grade Mechanical Engineer, 35, with successful record in operation, design and construction of modern steam power plants and at present works manager of concern manufacturing steam power plant equipment desires executive or sales position. Address Box 954, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

SALESMEN AND AGENCIES

SALES ENGINEER — MECHANICAL — desires additional account for Philadelphia territory. Has been selling power plant trade for five years. Box 963, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

WANTED: Salesmen or Manufacturers' Agents calling on Power Plant Engineers for Illinois, Indiana, West Virginia and Pennsylvania. Product sold to Industrial Plants, Hotels, Laundries, Hospitals, Etc. Many of the largest Industries in the Country have used our Product repeatedly over a period of years. Exceedingly liberal commissions and complete Sales Co-operation to good Representatives. When writing give particulars regarding present lines carried, territory now covered. Confidential. Write B. A. Hoffman, Salesmanager, 10116 Detroit Avenue, Cleveland, Ohio.

MANUFACTURERS AGENCY WANTED—Manufacturer of steam saving equipment wants connection with firms to take over the alonesale for different districts for our electrical Boiler Scaling Machines, air driven tube cleaners, CO_2 recorders, Oil Filters, Steam Traps. Our prices can compete with all others. Tickets marked D. F. A. 3371. Dorland Advertising, Ltd., 101 Park Ave., New York, N. Y.

SALES REPRESENTATIVE—Have you a long standing acquaintance with boiler room trade? Could you sell a good plastic furnace lining, priced right, commission basis? Syrosil Company, Elkhart, Indiana.

COMPANIES WANTING SALESMEN are using these columns to secure the right kind of men for their sales organizations. These lines are being read by hundreds of engineers. There is still some space available in the next issue which will be allotted to those companies whose orders are received first. Address: Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

SALESMEN to sell stokers, grates, etc. Exclusive territory. Budd Grate Company, 2011 E. Hagert Street, Philadelphia, Pa.

PATENTS AND PATENT ATTORNEYS

PATENTS—Booklet free. Highest references. Best results. Send drawing or model for search and advice. WATSON E. COLEMAN, Registered Patent Lawyer, 724 9th Street, Washington, D. C.

A Signboard Seen *from* Coast *to* Coast

If you are engaged in the power field and have a piece of equipment to sell, an engine, a motor, boiler, compressor, belt, or anything that is used in power plants and which you have laid aside, at a single stroke you can put your selling message where it will be seen, and read from coast to coast.

More than 23,000 power plant operators focus their eyes on this SIGNBOARD twice a month, looking for the things they need for their plants.

Not only is second-hand machinery sold and bought through the words blazoned here, but first-class men are found for every power plant opening.

The cost of displaying a message on this great Signboard is less than the cost of writing to even two or three hundred of the engineers who need it.

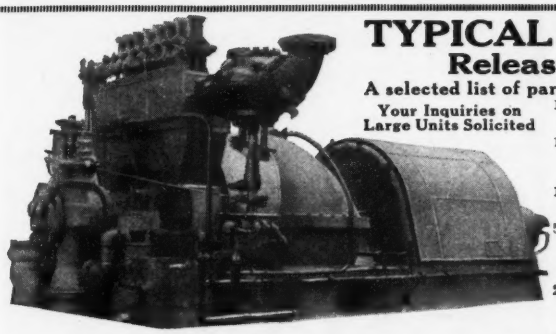
This Signboard is seen from coast to coast. It is the Signboard Section of Power Plant Engineering.

Write Your Message on It

SIGNBOARD SECTION

Quick Action Opportunities

EQUIPMENT FOR SALE | EQUIPMENT FOR SALE | EQUIPMENT FOR SALE



TYPICAL OF A MAGNIFICENT TURBO
Released Thru American Expansion

A selected list of par turbos now available for quick shipment at a saving of over 50%

Your Inquiries on Large Units Solicited

TURBO UNITS

1—12500 KVA G. E., 60 cycle, 200 lb., Condensing, with Jet Condenser, 100% internal excellence.
1—10000 KVA Westinghouse Parsons, 60 cycle 200 lbs., Condensing, with Condenser, 100% internal excellence.
1—9000 KVA (8000 KW) 80% PF Westinghouse CW Frame, impulse and reaction, 60 cycle, 200 lb., Condensing, economy 13 lbs., with Surface Condenser, 100% internal excellence.
1—7500 KVA Curtis 25 cycle Condensing Turbo, economy 15 lbs., complete with Condenser and all auxiliaries; 200 log operating days on standing service only.
1—5000 G. E. Curtis, 60 cycle, 3600 RPM, 200 lbs., with Surface Condenser, new equivalent.
1—3000 KW (3750 KVA) 60 cycle, Curtis Condensing Turbo Unit, 3600 rev., economy 14 lbs., log operations 7,000 hours, complete unit.
1—1875 KVA G. E. Curtis, 60 cycle, 3600 rev., Condensing, 200 lb., complete installation, including Jet Condenser.
5—1500 KVA Westinghouse CW and Parsons Condensing, Mixed Pressure, Non-condensing and Bleeder Type Units, 60 cycle, standard characteristics, with Jet and Surface Condensers.
2—937 KW 80% PF Westinghouse Parsons Condensing and Non-condensing, standard characteristics, 3600 rev., with Condensers.
2—750 KW Westinghouse Condensing, Non-condensing and Bleeder Turbos, 3600 rev., 60 cycle, with Jet and Surface Condensers.
2—300 KW Westinghouse Condensing or Non-condensing, 60 cycle, 3600 rev. turbos with Surface and Jet Condensers.

ENGINE SETS

1—800 KW 80% PF, G. E. ATB Altrn., 60 cy., std. charts, DC at 100 R.P.M. with Heavy Duty Allis-Chalmers Corliss.
1—600 KW 80% PF, G. E. ATB Altrn., 60 cy., std. charts, DC at 150 R.P.M. with Heavy Duty Filer and Stowell Corliss.
1—625 KVA West., 60 cy., Altrn., Cross C, 4 val. H. D. Engine.
1—300 KW G. E., R. F. Altrn., with Uniflow engine.
2—100 KVA R. F. Eng. Type Altrns., Modern 4 val. engine.

Must Remove Immediately

A. C. CORLISS UNITS

3 Phase 60 Cycle 2300-600-480-240 Volts

1—450 KVA. General Electric alternating current generator 150 RPM. direct connected to 23"x28" Chuse non-condensing Corliss engine.
1—675 KVA. General Electric alternating current generator 150 RPM. direct connected to 26"x32" Chuse non-condensing Corliss engine.

All excellent condition—located Ponca City, Okla.

WILL SACRIFICE FOR QUICK SALE WRITE, WIRE OR PHONE FOR DETAILS AND PRICES

THE NATIONAL POWER MACHINERY COMPANY
1907 Scranton Road Cleveland, Ohio

16 B&W Stirling Boilers
435 H.P.

16-435 HP. B & W Stirling type water tube boilers, hand fired, 180 lb. steam pressure. Each equipped with double superheater and auxiliaries as in operation. Excellent condition.

Must Remove Immediately—Bargain for Quick Sale

The National Power Machinery Co.
1907 Scranton Road Cleveland, Ohio

A. C. UNITS

210 KVA G. E.—19x20 Ames Uniflow Engine, 5 lbs. b.p., installed 1923, like new, seen operating, $4000.
300 KVA G. E.—20x36 Al. Chal. Corliss Engine, $4250.
325 KVA Al. Chal.—21x22 Skinner Uniflow, $5500.
150 KVA Wghse.—17x16 Erie Ball Engine, like new, $2000.
75 KVA G. E.—14x15 Skinner, $1050.
90 KVA G. E.—13x14 Erie Ball, $1500.
90 KVA G. E.—14x15 Harrisburg Uniflow, $1500.
150 KVA G. E.—15x16 Skinner, $2000.
150 KVA (2) G. E.—15x16 Skinner Uniflow, $3000.
375 KVA G. E.—22x26 Harrisburg 4 v., $4000
400 KVA Ridgway—26x24 Ridgway, $4250.

Power Plant Equipment Co. Inc.
39 Cortlandt St., New York, N. Y.

For Sale
250 Kva. Uniflow Set

240-480 V. 60 Cy. 3 Ph. G. E.
Engine 20x24, 200 R.P.M.
Practically new, non-condensing; a bargain.
NEW 1001 H. P. BOILER, 200 LB.
1000-1500 G.P.M. Underwriters Pumps
ROSS POWER EQUIPMENT CO.
Indianapolis, Ind.

WANTED—GENERATOR

Twenty-five kilowatt 220 volt direct current and direct connection gasoline driven generator. Write.

SOUTHEAST MISSOURI STATE TEACHERS COLLEGE
Cape Girardeau, Mo.

CONDENSER BARGAINS

SURFACE TYPE—2000; 4000; 5000; 6000; 7000; 25,000 Sq. Ft.
LEBLANC JET TYPE—300; 500; 1000; 1500; 2000; 3000; 5000; 8000; 10,000 KW Capacity Units.

PAUL STEWART & COMPANY
Turbo & Power Specialists, Cincinnati

FOR SALE

2 Collins Self-Feed Tube Expanders, 3½" and 4".
2 Steam or air driven boiler tube cleaners, for straight tubes—3½" and 4".
2 Roller Tube Expanders, 3½" and 4".

Box 962
POWER PLANT ENGINEERING
Chicago, Ill.

WANTED
STEAM ENGINE

A 400 to 500 kw. dependable used Unit to parallel with a 600 kw. compound wound Interpole 250 volt, 120 r.p.m. Generator.

Cereal Products Co.
Manitowoc, Wis., U. S. A.

ROTARY PUMPS WANTED

Exporter purchasing $10,000 worth rotary pumps desires full particulars and literature from manufacturers only. Prices must be competitive. Box 965, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

FOR SALE

360 K. V. A.—Type A. Q. B.—440 Volt—3 Phase—60 Cycle—360 R. P. M.—General Electric Belted Generator. Can be used for Synchronous Motor. Generator is in first class condition.

THE DAVEY COMPANY
Downingtown, Pa.

Turbo Generator Set

125 KVA—2300 volt, 60 cycle. 3 phase Condensing TURBO GENERATOR SET consisting of a Kerr Turbine with Allis-Chalmers Generator with direct connected exciter. 800 Sq. Ft. Wheeler Surface Condenser with auxiliaries, inter-connecting piping, all in first class condition. Will Sacrifice.

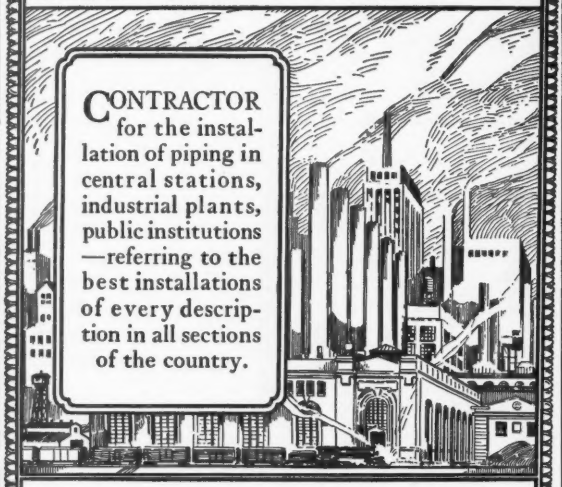
SMITH & WHITNEY
2017 Cedar Spring Road, Dallas, Texas

POWER PLANT EQUIPMENT

1—1000 KVA Westinghouse turbo generator.
1—3750 KVA General Elec. turbo generator.
1—1875 KVA General Elec. turbo generator.
1— 750 KVA New General Elec. turbo generator.
1— 250 KW Westinghouse-Skinner Unaflow unit.
1— 135 KW General Electric-Skinner Unaflow unit.
1— 300 KW, 250 volt, Gen. Elec. rotary converter.

Many other items of Electrical Machinery
GEO. SACHSENMAIER CO.
8405 Hegerman St., Holmesburg, Philadelphia, Pa.

PIPING CONTRACTOR



CONTRACTOR for the installation of piping in central stations, industrial plants, public institutions—referring to the best installations of every description in all sections of the country.

WILLIAM A. POPE
Associates
WILLIAM H. MILLER R. A. WIDDICOMBE
S. AUSTIN POPE
26 North Jefferson Street, Chicago
Licensee: Sargol Joints (Patented)

The compactness, simplicity and ease of operation of "Toledo" tools is a well known fact to thousands of engineers who use and praise these highly efficient pipe threading and cutting tools. If not already "Toledo" equipped ask us for catalogue.

THE TOLEDO PIPE THREADING MACHINE CO.
TOLEDO OHIO.

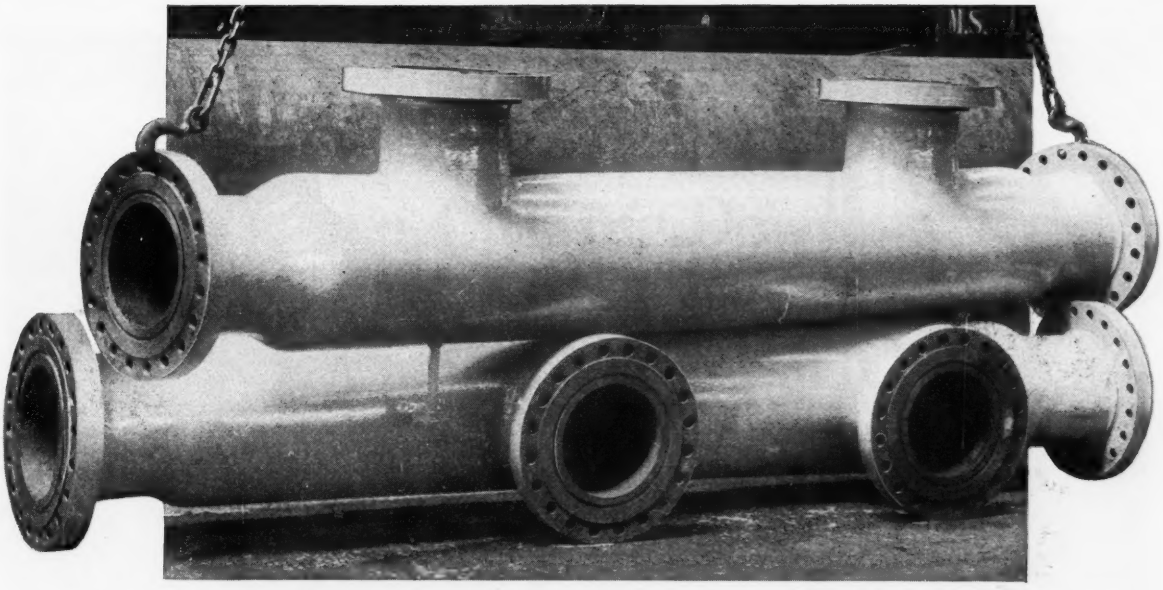
"TOLEDO"
TRADE-MARK REGISTERED

THE MULTI-BOND CHROME ORE CEMENT
Shipped Dry in Steel Containers, 200 Lbs. Net Weight
KROMEPATCH
REG. U.S. PAT. OFFICE
E. J. LAVINO AND COMPANY, Bullitt Bldg., Philadelphia

SUPERHEATERS
ELESCO
Peoples Gas Building Chicago Montreal Canada
Union Trust Building Pittsburgh London Paris
THE SUPERHEATER COMPANY
42nd STREET, NEW YORK, N. Y.

IMMEDIATE BOILER TUBE SERVICE
Straight and Bent Tubes for all Types of Boilers
WRITE FOR QUOTATIONS!
BOILER TUBE COMPANY OF AMERICA
3126 PREBLE AVE., PITTSBURGH, PA.
CHICAGO NEW YORK

Pittsburgh Piping & Equipment Co.
Pittsburgh, Pa.
1903 WHEN YOU THINK OF PIPING · THINK OF PITTSBURGH PIPING · PP&EC 1928
TWENTY-FIVE YEARS EXPERIENCE SUPPLYING FABRICATED MATERIALS AND INSTALLING COMPLETE PIPING SYSTEMS.
New York 220 Broadway · Chicago Peoples Gas Bldg. · San Francisco Russ Bldg. · Cleveland Ulmer Bldg. · Detroit General Motors Bldg.
Houghton, Mich. Dee Bldg. · Indianapolis Traction Terminal Bldg. · Boston 10 High St. · Dallas, Texas Am. Ex. Bk. Bldg.
Los Angeles—Bartlett Bldg.



Two Kellogg Forge and Hammer Welded Headers, made for the Pacific Gas & Electric Company's Station "C" at Oakland, Cal.

Forge and Hammer Welded Headers for 600 lbs. pressure

THE use of Kellogg Forge and Hammer Welded Headers eliminates the uncertainties that are present when steel castings are used. This is particularly true for the higher steam pressures that are rapidly becoming common practice. When headers such as those illustrated form part of a power plant piping system, permanent tightness is assured and number of joints reduced to a minimum. Erection, insulation and maintenance costs are consequently lessened.

The pieces shown above are for 600-lb. working pressure, and are typical Kellogg Forge and Hammer Welded products. These headers are 22-in. O. D., 15 ft. long and are swedged on one end to 16 in. and on the other end to 18 in. End flanges are hammer welded. Each is fitted with two 16-in. flue type forge welded outlets, and one 1-in. drain nozzle. Flanges have tongue and groove faces. The test pressure 1000 lbs.

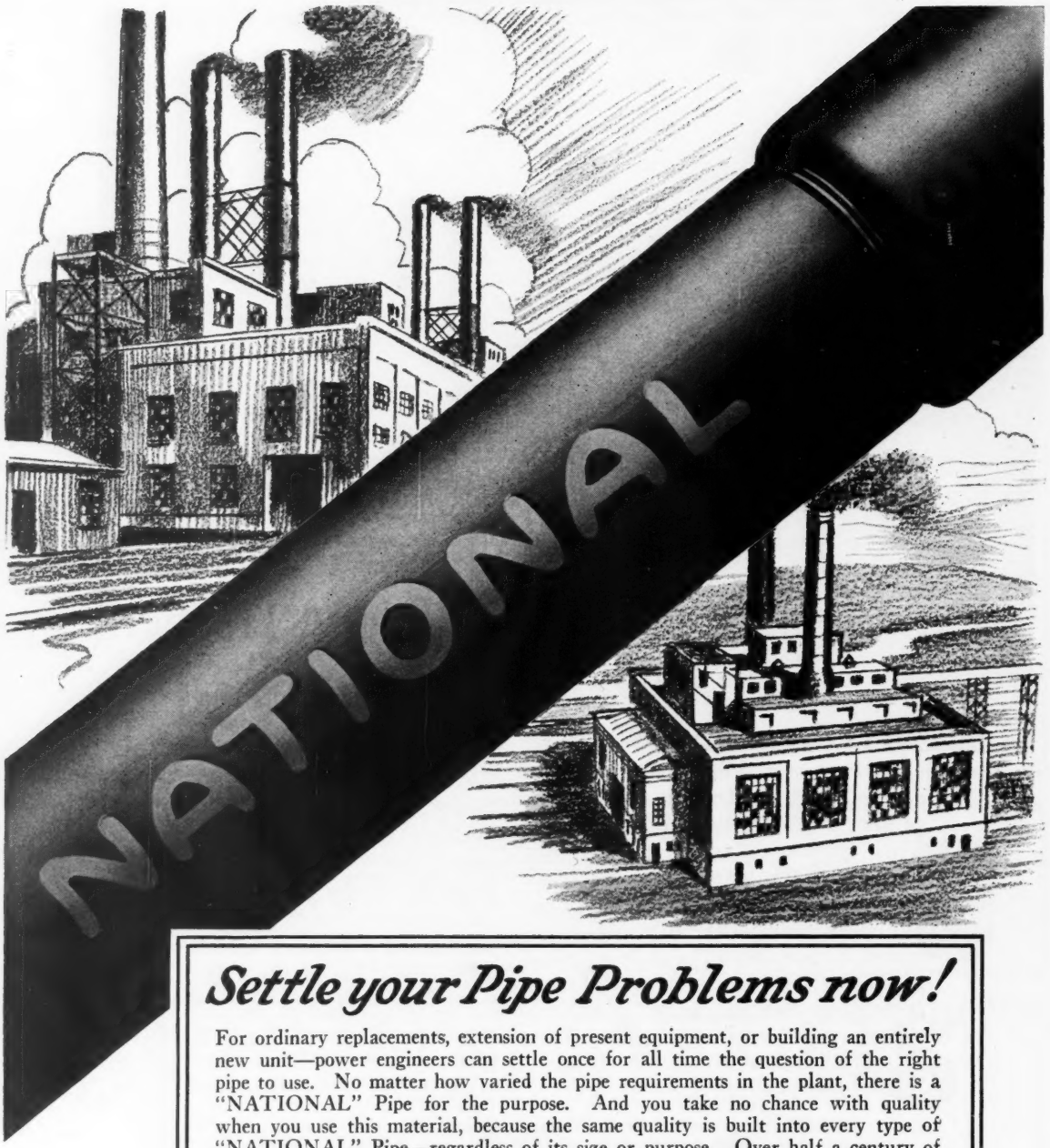
In addition to pieces such as the Pacific Gas & Electric Co. headers, The M. W. Kellogg Co. design and produce complete piping systems for power plants. Engineers and others concerned with planning installation or maintenance of power plant piping are invited to write for the Kellogg Booklet "Industrial and Central Station Piping."

THE M. W. KELLOGG CO., 7 DEY ST., NEW YORK
Birmingham, Alabama—827 Brown-Marx Bldg.
Boston—12 Pearl Street
Chicago—53 W. Jackson Boulevard
Pittsburgh—Oliver Building
San Francisco—2929 Harrison St.

KELLOGG

POWER PLANT PIPING ~ FORGE WELDED PIPE
FORGE WELDED CONTAINERS ~ RECEIVERS ~ SEPARATORS

ALL KELLOGG FORGE AND HAMMER WELDED PRODUCTS ARE INSURABLE



Settle your Pipe Problems now!

For ordinary replacements, extension of present equipment, or building an entirely new unit—power engineers can settle once for all time the question of the right pipe to use. No matter how varied the pipe requirements in the plant, there is a "NATIONAL" Pipe for the purpose. And you take no chance with quality when you use this material, because the same quality is built into every type of "NATIONAL" Pipe—regardless of its size or purpose. Over half a century of manufacturing experience behind the product, backed by the judgment of America's leading power plant specialists, justify your confidence in standardizing on one pipe for all power plant purposes. Available in all sizes, for any pressures, for any type of joint and for all kinds of bending and forming operations. Ask for Bulletin No. 10—written especially for Power Engineers.

NATIONAL TUBE COMPANY PITTSBURGH, PA.

NATIONAL PIPE

A Banroc Engineer Can Show You How to Cut Your Fuel Bills

LET a BANROC Engineer make a survey of the conditions in your plant. He will show you where your heat leaks are, and how to permanently, efficiently and economically stop them. Whether your trouble lies in your steam lines, boilers, breechings, ovens, or wherever you use heat, there is a BANROC Product made especially for it. Ask the BANROC Engineer to make you an estimate of the cost of insulating with BANROC and the heat it will save. No obligation.

Mr. B.T.U. Says:—

BANROC INSULATION has a conductivity rating given by the U. S. Bureau of Standards that makes it a leader in *Economical Efficiency.* It is this efficiency, plus permanence and economy that makes BANROC Products an outstanding value on the market.

Banroc Engineers are listed in the Phone Directories of the following cities:

BOSTON NEW YORK BUFFALO NEWARK DENVER PHILADELPHIA
PITTSBURGH CLEVELAND TOLEDO DETROIT LOS ANGELES
CHICAGO ST. LOUIS HOUSTON TULSA SAN FRANCISCO

BANNER ROCK PRODUCTS COMPANY, ALEXANDRIA, INDIANA

BANROC INSULATION

ORIGINATORS - OF - ROCK - WOOL - PRODUCTS

Pipe-Saver ready to insert

Pipe?

You can double its life *with Pipe-Savers*

You're putting in new sections of threaded pipe all the time.

You can make these sections last twice as long—or many times as long—by using Pipe-Savers.

The cost is negligible.

Pipe-Savers are simply a piece of tubular metal, shaped and flanged, which fits snugly into the pipe and protects the weakened (threaded) part against the action of steam, water and acids.

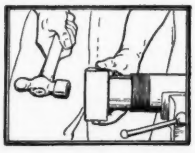
Pipe wears out first at the ends, which have been weakened by the threading and worn thru by the expansion-chamber action in the joint couplings.

Pipe-Savers have been tested for over four years under extreme conditions. They have never worn out. They make the weakest part of the pipe the strongest. They are fully **guaranteed.**

They not only save the pipe, but far more important: they save the loss of production, the damage to property, the labor, time and material—that are wasted by leaks!

Always put Pipe-Savers into pipe that is to be threaded.

FREE: Write for Survey Book that will show you how much you yourself can save yearly by using Pipe-Savers, throughout. Also sample and name of nearest supply house.

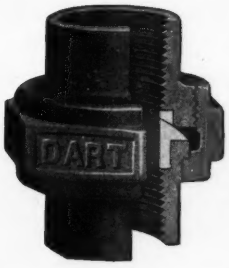


After the pipe has been reamed ready for fitting, insert Pipe-Saver. Seat by striking with a block of wood held against Pipe-Saver flange. The flange threads into the fitting.

PIPE-SAVER CORPORATION OF AMERICA
DEPT. 506 CARTHAGE, NEW YORK

Pipe-Savers

DOUBLE THE LIFE OF PIPE



DART UNIONS —a complete line that is guaranteed

Use them where service must not fail!

The bronze-to-bronze seats in Dart Unions are anchored in heavy malleable iron ends and are ground together. Doubly insured by careful workmanship, besides the best of materials, these unions come in all sizes and types and satisfy the demands of the country's leading engineers who select them for their extraordinary service.

Over thirty years ago, the E. M. Dart Manufacturing Co. started making these unions with rust-resisting and non-corrosive seats, and now, backed by the experience of these years, Dart Unions hold a position of trust in the eyes of their users in leading plants and industries.

Write for Catalogue "T" and free sample union. Our guarantee gives you two new unions if ever a Dart fails through defective materials or workmanship.

E. M. DART MANUFACTURING CO.

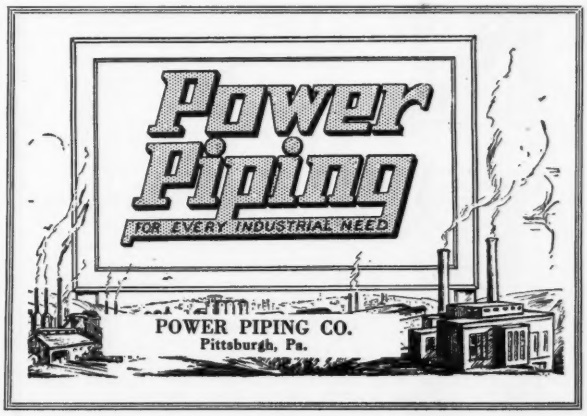
Providence, Rhode Island

Sales Agents: The Fairbanks Company, New York, and at all branches
Canadian Factory: Dart Union Company, Ltd., Toronto, Canada

SEVENTY-FIVE years' intimate experience with piping in all its phases is responsible for outstanding quality of Grinnell fabricating service.

Address inquiries to Providence, R. I.

GRINNELL COMPANY



Hydraulic Gate Valve

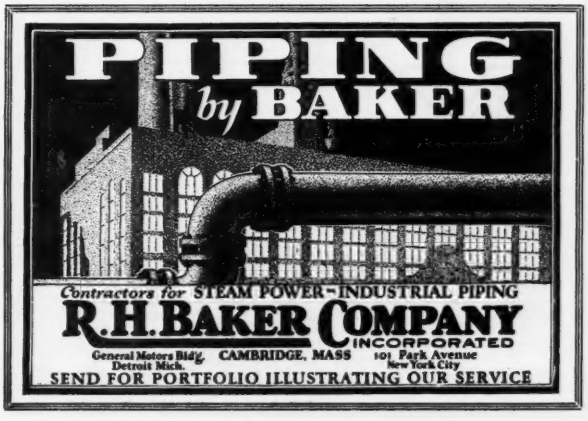
ATWOOD

High Pressure Piping

insures trouble-proof service whether it is a complete system, fabricated and installed by us, or a single Fitting, Valve, Interlock Welded Necks, Pipe Joints or any other part of a piping system. Write for full information.

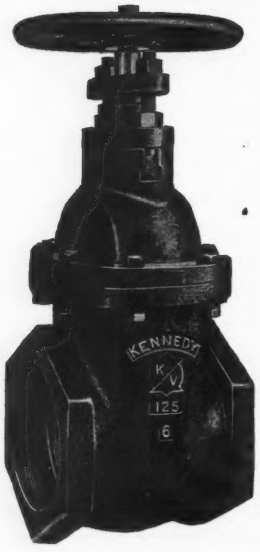
Pittsburgh Valve, Foundry & Construction Co.

26th St. and A. V. R. R. Pittsburgh, Pa.


PIPING by BAKER
Contractors for STEAM POWER - INDUSTRIAL PIPING
R. H. BAKER COMPANY
INCORPORATED
General Motors Bldg. Detroit Mich.
CAMBRIDGE, MASS
101 Park Avenue New York City
SEND FOR PORTFOLIO ILLUSTRATING OUR SERVICE

VALVES
PIPE FITTINGS
FIRE HYDRANTS

KENNEDY



Kennedy Standard Iron Body Gate Valve for 125 pounds working steam pressure. Furnished with stationary stem or outside rising stem and yoke, and with screwed or flanged ends. One of the many Kennedy types for power plant service.

KENNEDY Valves are popular with operating men because they seat tightly, open and close easily, and can be depended upon for many years of trouble-free operation. Kennedy Valve installation No. 1, now over 50 years on the job, is today in active service, and the hundreds of Kennedy Veterans that are still too good to be retired after a quarter century or more of service testify to the thorough-going merit of Kennedy design and construction.

Send for the Kennedy Catalog

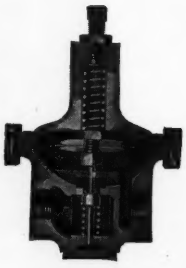
The Kennedy Valve Mfg. Co.
Elmira, New York

WAREHOUSES: New York, 128-132 White Street; Chicago, 1335-1337 S. Clinton Street; San Francisco, 448-450 Tenth Street.

SALES OFFICES: New York, Boston, Philadelphia, Cleveland, Chicago, Atlanta, Salt Lake City, El Paso, Los Angeles, San Francisco, Seattle.

Maintain Predetermined Steam Pressure

on low pressure work by installing the compact, simple, reliable



Strong Reducing Valve

Will reduce any initial pressure not exceeding 150 lbs.

Equipped with a strainer to take dirt and scale out of line.

Valve has a single seat and disc made of Anum-Metl (copyrighted) —guaranteed tight for One Year. Three sizes: ½", ¾", 1".

Write for Fuller Description

The Strong, Carlisle & Hammond Co.

Manufacturers of a Complete Line of
Steam, Radiator and Vacuum Traps, Steam and Oil Separators, High and Low Pressure Reducing Valves, Pump Governors, Engine Stops, Emergency Check Valves, Evrtyte Globe Valves, etc.

1392-94 W. Third St., CLEVELAND, OHIO

ADSCO

***Duplex-Sleeve Guided* Expansion Joint**

For high pressure and superheat. Air-cooled slip eliminates excessive packing and maintenance costs and assures a tight joint. One of thousands of sizes and types of ADSCO Expansion Devices for pipe lines carrying steam, water, oil, air, gas or liquids.

AMERICAN DISTRICT STEAM COMPANY
GENERAL OFFICES AND WORKS
NORTH TONAWANDA, N.Y.

FABRICATION ERECTION

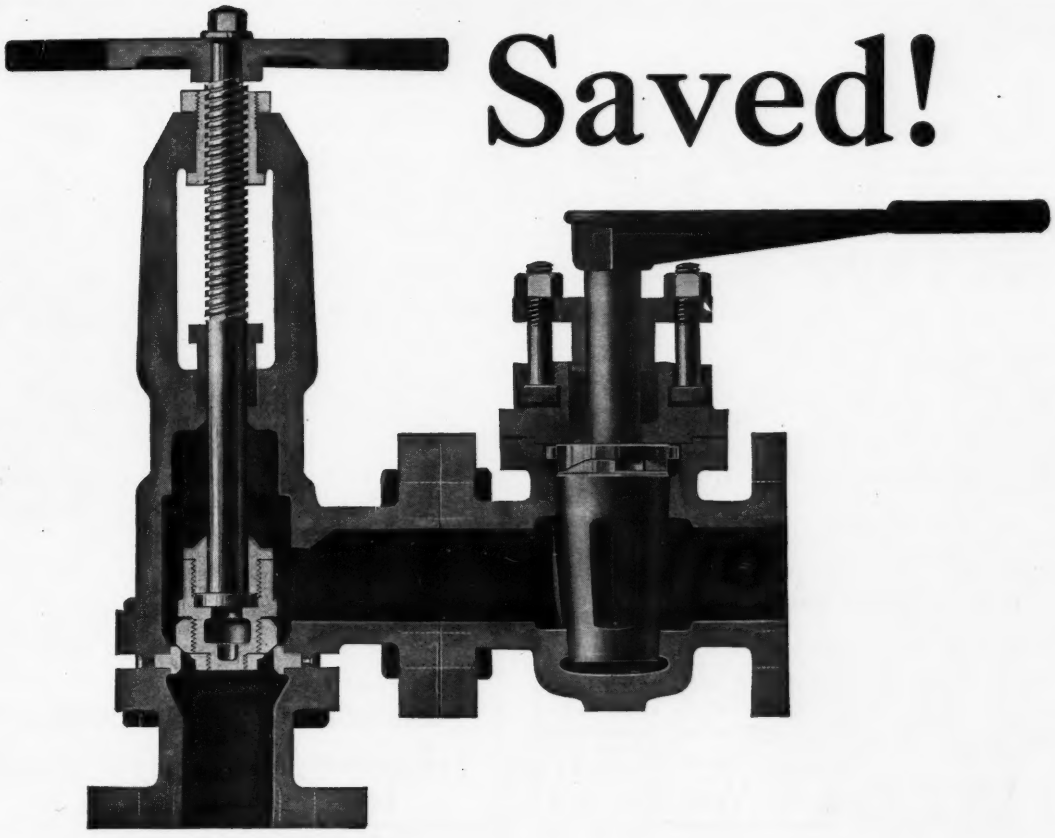
FORGE PIPE OR GAS AND TUBING WELDED HEADERS

HIGHEST SUPERHEATED STEAM PRESSURES AND TEMPERATURES

NAVCO

ALL TYPES PIPE JOINTS COMPLETE POWER PIPING INSTALLATIONS

NATIONAL VALVE AND MANUFACTURING COMPANY
PITTSBURGH PENNSYLVANIA U.S.A.
ATLANTA CHICAGO CLEVELAND COLUMBUS NEW YORK PHILADELPHIA



Saved!

$24.71 per Boiler per Year with HOVALCO-HOMESTEAD

Combination Blow-off Valves - - -

This is the actual figure revealed in a recent survey of the plant of a nationally known manufacturer of soap powder.

The Hovalco-Homestead Valves had been in service eight years and compared to former equipment showed a saving of $24.71 per boiler per year. In other words a 60% saving in actual cost of operation over former equipment. This saving does not include the amount saved through stopping leakage.

This combination is showing a similar saving in Central Stations, Industrial Power Plants and many other plants.

If you are interested in economical, care-free valve service for blow-downs you will want to investigate Hovalco-Homestead. We also make the well known Homestead Quarter-Turn, Protected Seat Globe Valve and Homestead-Ross Quick Opening Air Valve.

Write for Catalog.

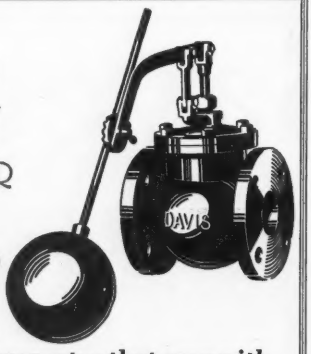
Homestead Valve Manufacturing Company, P. O. Box "H," Coraopolis, Penna.

HOMESTEAD VALVES

QUARTER TURN VALVES:
STRAIGHT WAY
THREE WAY
FOUR WAY
LUBRICATED TYPE
ROUND OPENING REFINERY

PROTECTED SEAT VALVES:
HYDRAULIC (B & O. PAT.) OPERATING
REMOTE CONTROL
GLOBE
ROSS AIR SHUT-OFF VALVE
HOVALCO BLOW-OFF VALVE

WHAT DO YOU EXPECT FROM YOUR FLOAT VALVE?



Unbounded satisfaction is the guarantee that goes with every Davis Float Valve. Many years of service have proven the unusual merit of this automatic control valve. Used on the makeup line to an open tank, it will maintain the desired water level without a thought from anybody.

It's a single seated, tight closing valve. There is no internal packing. It will not leak or stick. It has a standard renewable disc—maintenance cost is negligible.

It's a distinctive valve that will please the most discriminating user. Try one.

Booth No. 82, Chicago Power Show, February 12-16, 1929

G. M. DAVIS REGULATOR CO.
429 MILWAUKEE AVE. CHICAGO, ILL.

Balanced Valve Pressure Regulator Steam Trap Back Pressure Valve
Stop and Check Valve Exhaust Relief Valve Non-return Valve
Butterfly Valve Float Box with Control Valve

DAVIS AUTOMATIC VALVE SPECIALTIES

Cadman Tandem

for all blow-off services!

the standard combination for modern practice

Handles all pressures

Combining the Cadman "Indestructible" Blow-Off Valve, with its reversible seat and disc, with the Cadman "Gato" Valve, the plug type, this Tandem has proved its value in industrial and power plants wherever it is used.

The advantages of both valves make this combination equal to all modern requirements. Experience gained through 64 years of valve production has resulted in this culmination of superior service.

Write for bulletins.

BARRETT MACHINE COMPANY
Specialty Division
We also manufacture the Mosher Steam and Oil Separators and Gauge Cocks
1430 Oliver Bldg., Pittsburgh, Pa.

TWO STURDY VALVES

EVERLASTING "DUPLEX" BLOW-OFF UNIT

Insures Perfect Seal and Dependable Blowing Service on Your Boiler Blow-Off Lines.

EVERLASTING VALVE CO.
JERSEY CITY, N. J.
Made in Canada by Everlasting Valve Co., Ltd., Toronto

LUNKENHEIMER VALVES AND ENGINEERING APPLIANCES

AMERICA'S BEST LUNKENHEIMER "QUALITY" SINCE 1862

Lunkenheimer Distributors, located in all industrial centers, can fill your requirements promptly.

THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO BOSTON PHILADELPHIA
PITTSBURGH SAN FRANCISCO NEW ORLEANS
LONDON
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

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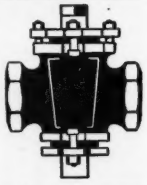
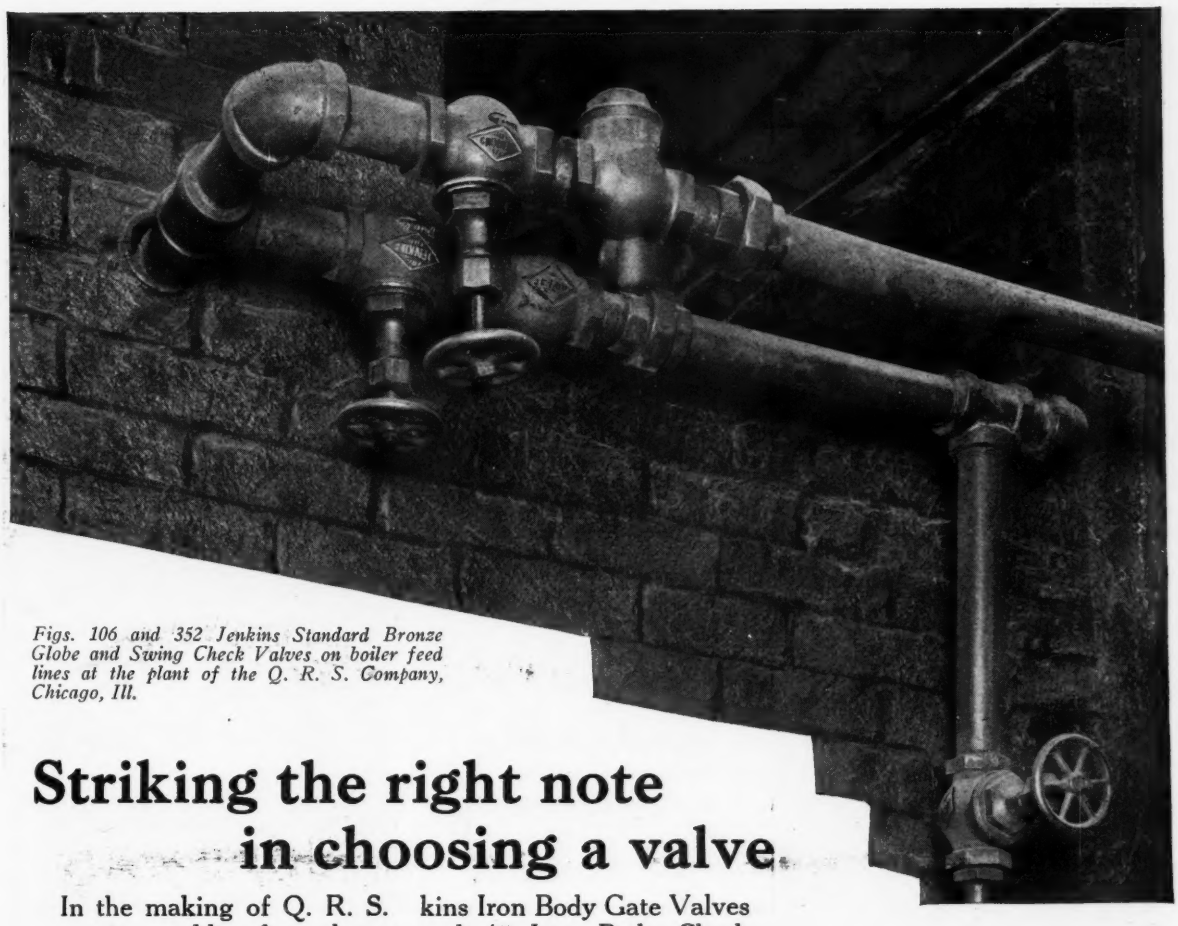
NORTHERN DOUBLE PACKED VALVES



BALANCED - LUBRICATED
CAN'T STAY STUCK
CAN'T KEEP LEAKING

NORTHERN PUMP CO.
MINNEAPOLIS, MINN.
OFFICES IN ALL PRINCIPAL CITIES



Figs. 106 and 352 Jenkins Standard Bronze Globe and Swing Check Valves on boiler feed lines at the plant of the Q. R. S. Company, Chicago, Ill.

Striking the right note in choosing a valve

In the making of Q. R. S. music rolls for player pianos, care is taken to strike the right note in the selection of plant equipment. The note of true valve economy was sounded when Jenkins Valves were installed in large numbers in the Chicago plant of the Q. R. S. Co.

On the headers are Jenkins Automatic Equalizing Stop and Check Valves. In the boiler feed lines are Jenkins Bronze Globe Valves and Bronze Swing Check Valves. In lines to boiler feed pumps, 3″ and 4″ Jenkins Iron Body Gate Valves and 4″ Iron Body Check Valves are in service.

The types of valves used in this one plant illustrate the range of the Jenkins line. There's a Jenkins for practically every requirement, obtainable through supply houses in every section of the country.

JENKINS BROS.
80 White Street.....New York, N. Y.
524 Atlantic Avenue.....Boston, Mass.
133 No. Seventh Street...Philadelphia, Pa.
646 Washington Boulevard...Chicago, Ill.
JENKINS BROS., Limited
Montreal, Canada.....London, England
FACTORIES:
Bridgeport, Conn.....Elizabeth, N. J.
Montreal, Canada

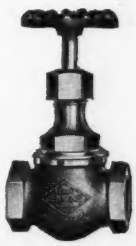


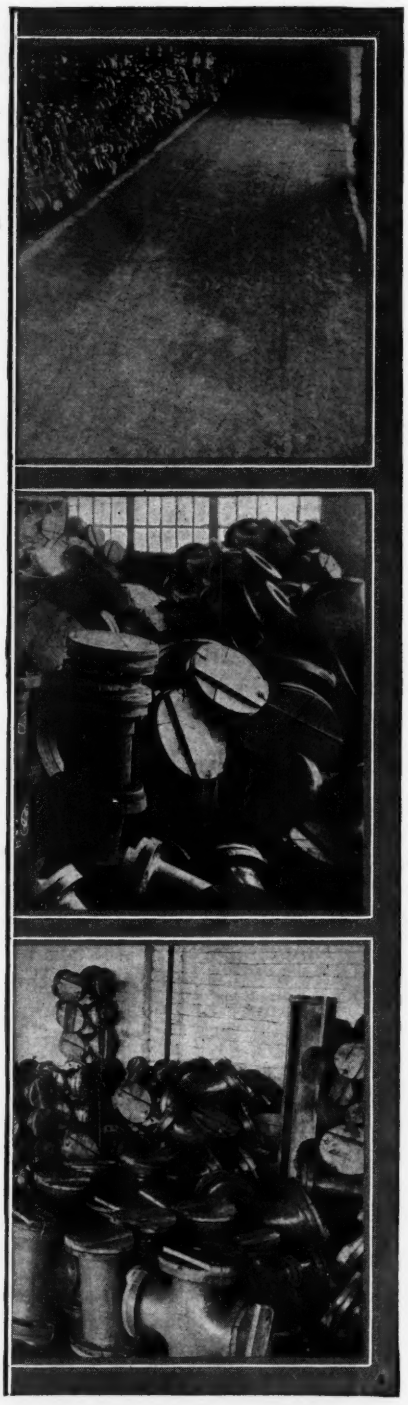
Fig. 106
Jenkins Standard Bronze Globe Valve, Screwed

Fig. 352
Jenkins Standard Bronze Swing Check Valve, Screwed

Always marked with the "Diamond"
Jenkins Valves
SINCE 1864

Just a few of the Walworth SIGMA STEEL Valves and fittings in stock at our Greensburg and Kewanee plants and in the warehouses of Walworth distributors in all principal cities

SIGMA HAS SWEPT SUSPICION FROM STEEL
TRADE WZ MARK



WALWORTH

Walworth Company, General Sales Offices: 51 East 42nd St., New York
Plants at Boston, Mass.; Kewanee, Ill.; Greensburg, Pa., and Attalla, Ala.

Distributors in Principal Cities of the World

Walworth Limited, 10 Cathcart St., Montreal, P. Q.
Walworth International Co., 11 Broadway, New York, Foreign Representative

These two 10" by 20"
VENTURI REDUCING VALVES

handle heating steam

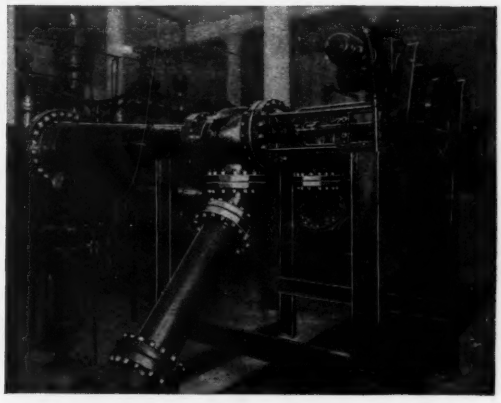
at the

Baltimore Avenue Heating Plant

of the

Kansas City Power & Light Co.

Each valve handles from
5000 to 125,000 lbs. of steam per hour,
reducing pressure from 160 lbs. to 20 lbs.

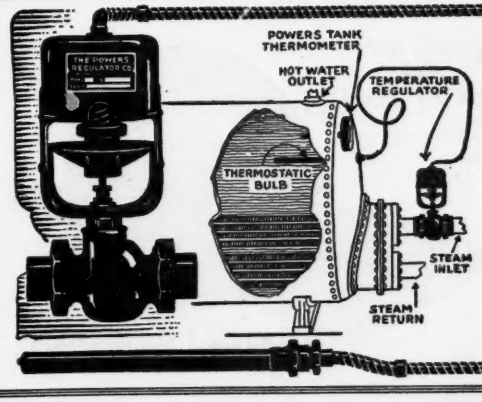


SCHUTTE KOERTING

Consider these features:

Motor operated flow regulating valve, expansion nozzle for pressure reduction, automatic control for valve motor. Built for pressures up to 1400 lbs.

1156 THOMPSON ST., PHILADELPHIA, PA.



Get Bigger Profits With This Regulator

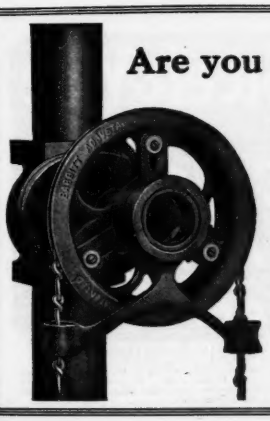
Wherever an exact temperature affects your profits, use a POWERS REGULATOR. The loss of just one batch of spoiled product, caused by temperature being *too hot* or *too cold*, would often pay for a regulator like the one shown here. It is used to ACCURATELY control the temperature of liquids in steam heated vats, tanks, and kettles. Is easy to install—lasts for years. Often pays for itself two or three times a year.

Write for Bulletin

THE POWERS REGULATOR CO.

36 years of specialization in temperature control

2769 GREENVIEW AVENUE, CHICAGO. Also New York, Boston, Toronto, and 31 other offices. See your telephone directory (11-3259)



Are you waiting for ?

someone to break his neck before you put Babbitt Rims on your overhead valves?

Don't Wait! It's Bound to Happen If You Do!

Don't Delay! Buy Now! Safety First!

Babbitt Steam Specialty Co., Inc.
55 S. Water St.
New Bedford, Mass.

EDWARD

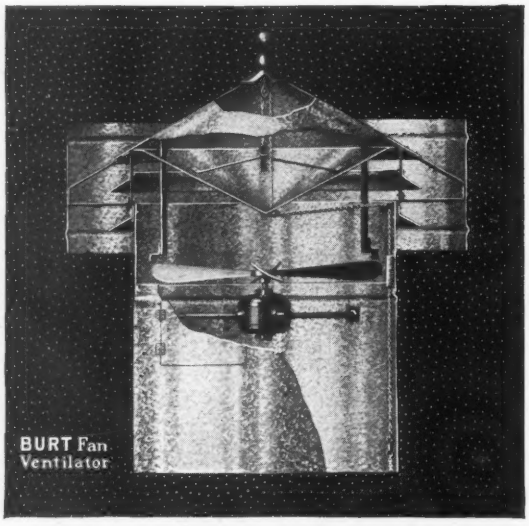
High Pressure—High Temperature Valves—Non-Return—Stop —Feed Line—Blow-Off—Check—Atmospheric Relief

Forged Steel Valves—400, 600, 900 lb. W.S.P. Stds. Built in Globe & Angle pattern & in a range of sizes & types

Ferac Valves — Non-Return and Stop for service up to 250 lb. W.S.P. and temperature to 500° F.

The Edward Valve & Manufacturing Co.
East Chicago . . . Indiana

VALVES



Closed Window Season Is Here

Time for coughing and sneezing, dead dragging afternoons and all the other inefficiencies of bad air conditions.

Because it definitely drives out bad air with a direct connected electric fan, the Burt Fan Ventilator will do the work of five or six ordinary gravity type ventilators. The initial cost for an effective installation is lower and the job better done.

Where conditions are not so bad, another style of Burt Ventilator may do the job. There is a size and type to meet every condition.

Factory built of metals 2 to 4 gauges heavier than other makes, Burt Ventilators last longer and work better. Let us figure on your ventilation problems.

BURT
Exhaust Heads

Save roofs, buildings, and boilers and they last a lifetime. Made in two types and all sizes.

BURT
Oil Filters

Burt Oil Filters are cutting lubricating costs in thousands of plants. There is a type for every purpose and capacity.

The BURT MFG. Co.
Ventilators-Oil Filters-Exhaust Heads
44 E. South St. Akron, Ohio

PARKER
Wherever men use pipe
PARKER TUBE COUPLINGS
are in demand and available in correct size, shape and metal.
THE PARKER APPLIANCE CO.
10320 BEREA ROAD, CLEVELAND, O.
U. S. A.
P-376 P-334

"CATAWISSA" *Extra Heavy*
Hot Forged Steel Unions
—Masters of the Highest Temperatures and Pressures in Modern Plants

Write
The Central Forging Company
Catawissa, Pa., U. S. A.
for bulletin with list prices

Kerlow Steel Floors
222-238 CULVER AVE.
JERSEY CITY, N. J.

Non-Slipping

American Steel & Wire
American Company's
Wire Rope
and **AERIAL WIRE ROPE TRAMWAYS**

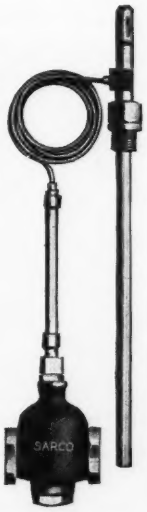
AMERICAN STEEL & WIRE COMPANY
Sales Offices: Chicago, New York, Boston, Atlanta, Birmingham, Cleveland, Worcester, Philadelphia, Pittsburgh, Buffalo, Detroit, Cincinnati, Baltimore, Wilkes-Barre, St. Louis, Kansas City, Minneapolis-St. Paul, Oklahoma City, Memphis, Dallas, Denver, Salt Lake City, *San Francisco, *Los Angeles, *Portland, *Seattle. *United States Steel Products Co.

"What'll I do? Otto is home sick and no one knows how to tell the temperature of the mixture."

That's the predicament you may be in some day if you rely on men to do the work of temperature regulators. More goods are ruined, more shipments delayed and more customers lost than you probably realize by trying to save a few dollars initial investment in temperature regulators and making men "guess" at temperatures.

Once set for a given temperature, Sarco Regulators maintain exactly that temperature without attention, and any man can then tell the temperature.

The Sarco costs but little to buy and requires no expensive pipe lines to install, as it is entirely self-contained and needs no compressed air, water pressure or electricity to operate.



Let us send you a Sarco entirely at our risk. Try it for 30 days and then send it back if you are willing to part with it.

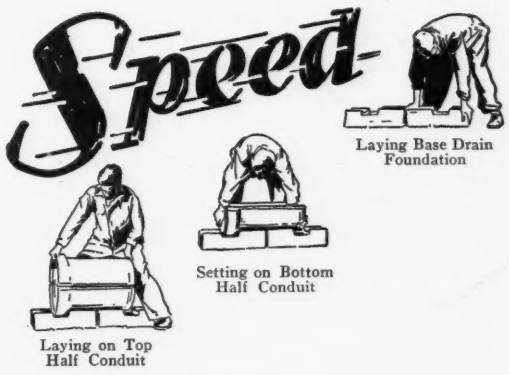
Write for free Booklet B-60.

SARCO CO., Inc.
183 Madison Ave., New York

Boston	Cleveland	Pittsburgh
Buffalo	Detroit	St. Louis
Chicago	Philadelphia	

Peacock Bros., Ltd., Montreal

SARCO
TEMPERATURE REGULATOR



Only 3 Pieces to Handle in Each 2 Feet of Conduit

"THE thing I like about Ric-wiL—and it's a big New York contractor talking—is the speedy way it goes in the ditch. Simple—fast—only three pieces to handle for each two feet of conduit. Take your base drain—set 'em in the trench like a row of dominoes. Bottom half conduit—set it on the base drain, slots are all ready for the bells. Top half conduit—lay it in place. When the pipes are in, stuff it with filler and cement the joints. . . . Why it's only a fraction of the work required by conduits you have to build on the job."

Ric-wiL conduit goes in the trench with machine-like assembly. Its installation speed cuts your costs—there's no waste of either time or material.

These points, especially this year, account for the miles of Ric-wiL put in by some of the largest power and heating companies in the country. If you haven't the complete information on Ric-wiL—write today. Get all the facts.

The Ric-wiL Company
1564 Union Trust Bldg., Cleveland, O.

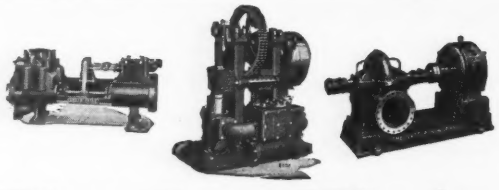
Originators of Waterproof Conduit Filler
RIC-WIL
UNDERGROUND CONDUIT

De Laval Worm Gear

A Superior Speed Reducer where other drives fail!

THIS 3.5 ratio De Laval Worm Reduction Gear is transmitting 75 HP. from a 720-RPM. motor to a pulverizer. The only attention required is occasional inspection to see that the proper oil level is maintained within the case.

De Laval Steam Turbine Co., Trenton, N. J.



Platt Iron Works

Dayton, Ohio

"Platt" and "Smith-Vaile" Pumps
Steam and Power Pumping Machinery

MANISTEE "ROTURBO"

CENTRIFUGAL PUMPS

ROTARY JET CONDENSERS

Manistee Iron Works Co. Manistee, Mich.

STAUNCH!

Staunch? Yes — Frederick Centrifugal Pumps "are there" always when they're needed to keep the plant running smoothly.

Frederick Pumps do not fail in the tight places: The *Best materials and correct design prevent it!*

FREDERICK PUMPS

THE FREDERICK IRON & STEEL CO., FREDERICK, MD.

Storage Batteries

By Morton Arendt.

Complete treatment of principles of action of batteries, details of construction and of care, operation and maintenance. Written specially for the man in charge of the plant to insure satisfactory service. 285 pp. Fully illustrated. Price $4.50.

POWER PLANT ENGINEERING
53 W. Jackson Blvd., Chicago, Ill.

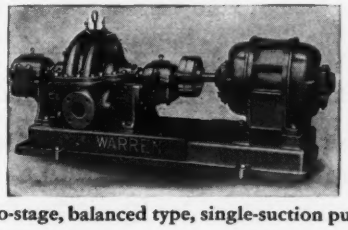
62
89
43
40
31
265

A total of 265 Warren Pumps purchased by 5 companies

Records tell the story! Each of these five manufacturers originally purchased one or two Warren Pumps. As a result of their performance under actual conditions — their sustained high efficiency and low cost of operation — repeat orders were placed until one of the manufacturers now has 89 in service, another 62, and the others 43, 40, and 31.

all within four years

Warren Pumps are built to live up to the claims made for them. Compare them part for part in design and construction with any other pumps. No effort has been spared to build them to deliver to the user the lowest possible pumping cost per year. Centrifugal and reciprocating types for every purpose. Write for illustrated, descriptive Bulletins.



Two-stage, balanced type, single-suction pump

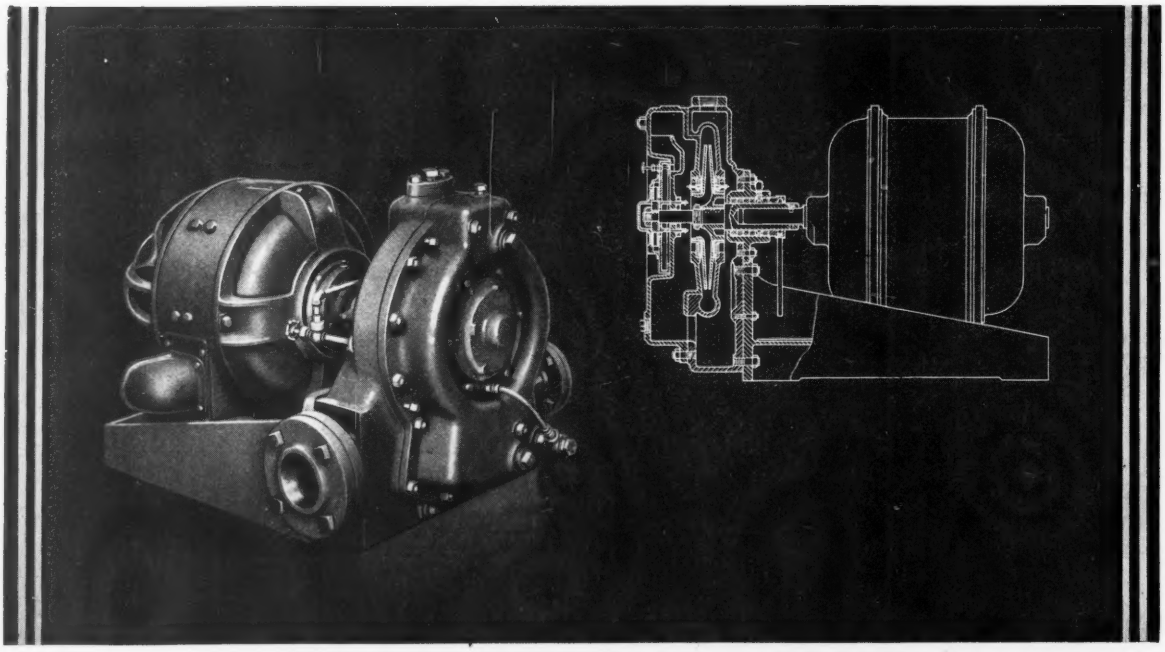
Warren

Steam Pump Company Inc. WARREN Warren Massachusetts

2368

AGENCIES IN PRINCIPAL CITIES

This centrifugal is self-priming!



External and sectional views of the motor-driven Jennings Suction (Self-Priming) Centrifugal Pump, 2 in. size

Delivers full rated capacity at starting without delay

Jennings Centrifugal Pumps are recommended for circulating hot and cold water; boosting city water pressure; handling water in air washing and conditioning; removing condensate from heating systems, blow down from soot blowers and superheaters, exhaust drips from steam ejector air pumps and other auxiliaries; pumping refrigerator can and core water, evaporator feed, cooling tower and condenser water, screen wash water, oil engine jacket water, ash sluicing water.

WHEN the Jennings Suction Centrifugal is started, the built-in Nash Vacuum Pump exhausts the air from the casing and suction piping. Water is quickly drawn into the pump. Full rated capacity is delivered without delay.

Besides this self-priming device, several other features are to be noted in the Jennings design. Motor armature, pump impeller and air rotor are mounted on the same shaft. Alignment is inherent. The only bearings are the two in the motor frame. One stuffing box has been eliminated.

Furnished in 2, 3, 4 and 5 in. sizes for capacities up to 1000 g.p.m. Heads up to 100 ft.

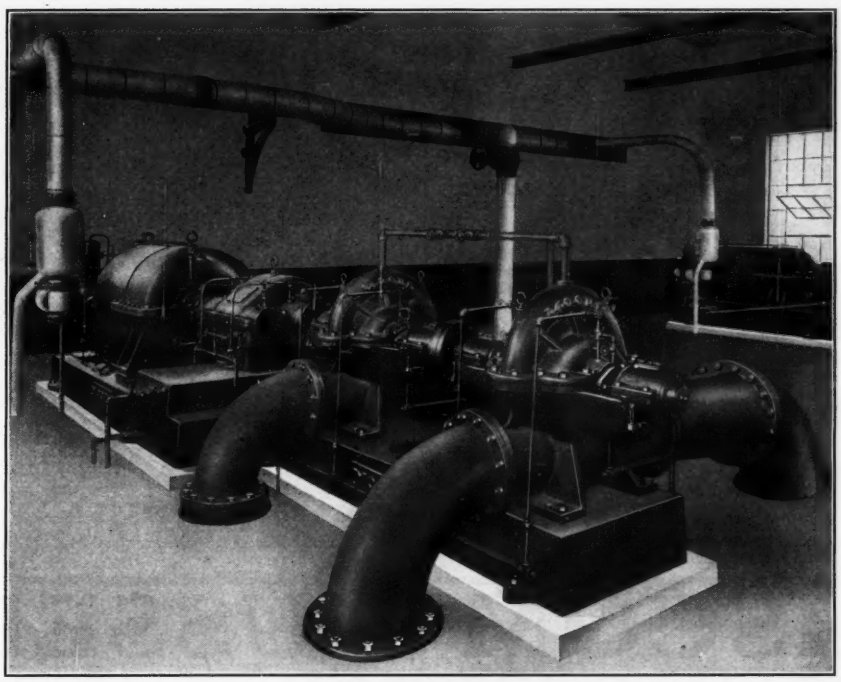
RETURN LINE AND AIR LINE VACUUM HEATING PUMPS ✻ CONDENSATION PUMPS COMPRESSORS AND VACUUM PUMPS FOR AIR AND GASES ✻ STANDARD SUCTION CENTRIFUGAL PUMPS ✻ MARINE PUMPS ✻ SEWAGE EJECTORS ✻ SUMP PUMPS ✻ FLAT BOX PUMPS ✻ HOUSE SERVICE PUMPS

Jennings Pumps

THE NASH ENGINEERING CO 169 WILSON ROAD, SOUTH NORWALK CONN.

MOORE

PUMPING UNITS USE 33% LESS STEAM



MOORE

"Best at every turn"

Greensboro, N. C., Waterworks

One of Two 8,000,000 GPD 310′ Head Moore Turbine Driven Pumping Units installed in the City Waterworks

Waterworks service must be highly economical and reliable. Read what this user has to say:

"We have just installed the steam flow recording gauges so that we are able to determine definitely the steam requirements of the various units in the plant. We find that our former large unit required that we develop 225 BHP when operating at a six million gallon rate, whereas your unit requires only 150 BHP. The fireman reports that we operate your unit continuously; has even remarked that the units run mostly on their reputation and require no steam whatsoever."

STEAM TURBINES—REDUCTION GEARS—PUMPS

MOORE STEAM TURBINE CORPORATION
WELLSVILLE, NEW YORK

Offices in all principal cities

In Canada: General Supply Co. of Canada, Ltd., Ottawa

De Laval Pumps

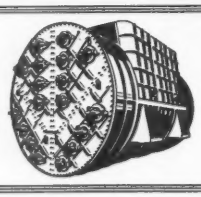
Keep the Plant Running

THIS De Laval Single Stage Pump is handling "white water" in a large paper mill, 24 hours per day, year in and year out. It is built in the regular De Laval manner, from the best of materials and with the highest grade workmanship, on a limit gage, interchangeable basis throughout. Parts exposed to wear are made of bronze, or protected by bronze wearing rings, sleeves, bushings, etc. Any ordinary workman can insert renewals when required, as they do not have to be fitted. Each De Laval Pump is guaranteed as to head delivery, efficiency and other characteristics, and is thoroughly tested before it leaves our Works.

State requirements and ask for Catalog B.

De Laval Steam Turbine Co., Trenton, N.J.

2944 40.759



Surface Condensers, Jet Condensers, Barometric Condensers, Leach Fracto Control Condensers, Oil Vapor Condensers for High Vacuum Distillation, Heat Exchangers, Sand Separators, Radojet Air Pumps for vacua up to 29.95 inches, Forced and Natural Draft Cooling Towers.

C. H. WHEELER MANUFACTURING COMPANY

19th St., Lehigh and Sedgley Aves. Philadelphia, Pa.

C. H. WHEELER of PHILADELPHIA

GRISCOM-RUSSELL

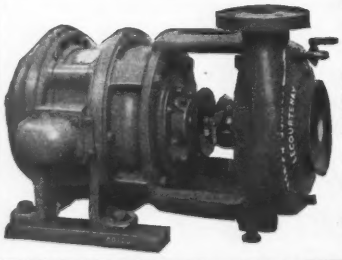
Evaporators—Feed Water Heaters—Extraction Steam Heaters—Generator Air Coolers—Lubricating Oil Coolers
Steam, Air and Oil Separators—Filters—Strainers—Expansion Joints

Described in bulletins which will be sent on request

THE GRISCOM-RUSSELL COMPANY, 285 Madison Avenue, NEW YORK

Branches in principal cities

CENTRIFUGAL PUMPS



TYPE H

COMPACT
RUGGED
EFFICIENT

5 to 250 GPM
Heads up to
350 ft. in one
single stage.

BUILDERS OF CENTRIFUGAL PUMPS FOR EVERY CONDITION

LECOURTENAY 7 MAINE ST. NEWARK, N.Y.

WORTHINGTON

PUMPS
Steam and Power
Reciprocating and Centrifugal

COMPRESSORS
Air, Gas and Ammonia
—Air Lifts

CONDENSERS
Surface, Jet, Barometric
—and vacuum auxiliaries
Steam-Air Ejectors

ENGINES
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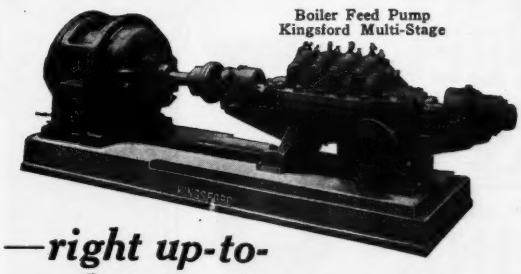
FEED WATER HEATERS
Locomotive and Stationary

METERS
Water and Oil

Worthington Pump and Machinery Corporation
2 Park Ave., New York City



Boiler Feed Pump
Kingsford Multi-Stage

—right up-to-date in dumping service

KINGSFORD

These multi-stage centrifugal pumps fulfill all the requirements of modern pumping conditions. The economy and durability which they assure are the result of thirty years of pump building. Get these advantages for your plant.

Write for Bulletin No. 56

Type SL, shown above, is a Four-Stage Motor-Driven pump which comes furnished with Babbitt-lined, Sleeve type, Oil ring bearings or with double-row, double-groove, radial ball bearings. Full details on request.

Kingsford Foundry & Machine Works
Oswego, New York

Better Performance Plus Power Savings

Westco Double Suction Pumps require one to two sizes smaller motors, 1750 r.p.m., than other type pumps.

Westco Pumps are single stage, turbine type. For many duties they will out-perform and outlast any other pump. Your files are incomplete without the latest Westco Catalog 10.

The Pump with the Wide Operating Range

Write today for Catalog 10

WESTCO-CHIPPEWA PUMP COMPANY

Factory and General Offices—Davenport, Iowa

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MARLEY

Spray Cooling Equipment

EFFECTS

BIG ECONOMIES

IN

Spray Pond Operation

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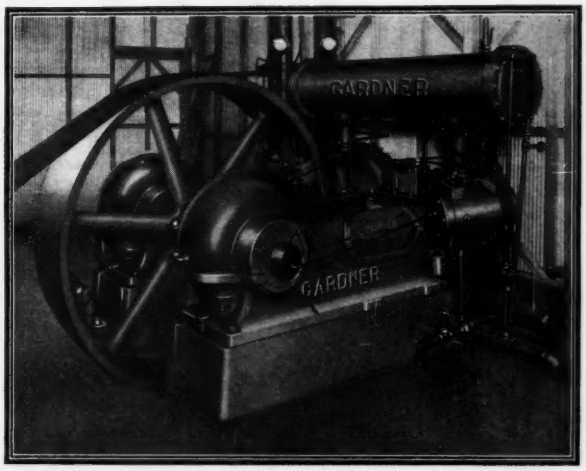
The Marley Company

(formerly Power Plant Equipment Co.)

1737 Walnut St., Kansas City, Mo.

Where Clean Assembly Is Vital



THE YELLOW TRUCK & COACH MFG. COMPANY maintains that continued and dependable performance of its products is greatly aided by extreme care in assembly.

All parts are thoroughly cleaned of dirt, grit and foreign matter by Gardner-Denver Compressors before they are assembled into the finished product.

All Gardner-Denver Products are built in the same careful manner—every part being exposed to a bath of clean, dry air before assembly.

Give your product a better send off and a better chance.

We would be glad to send you our bulletins XH-5, HAC-33 and HAC-34.

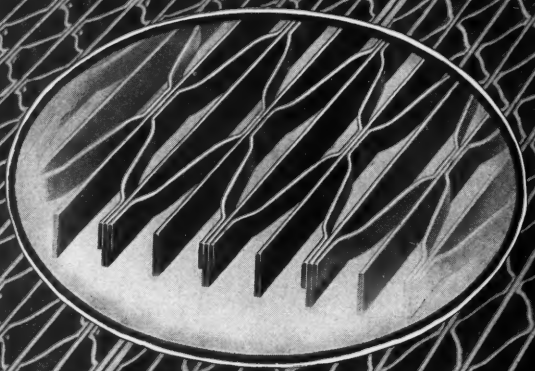
GARDNER-DENVER COMPANY

Quincy, Ill. Denver, Colo.

GARDNER DENVER

OPEN STEEL IRVING FLOORING

TRADE MARK SUBWAY REGISTERED



Two exclusive features left "IRVING" FLOORING out of the "grating" class. One:—the 2-depth bars assembled with all edges absolutely flush on one face—nothing to trip or stumble over. Two:—the distinctive shape of mesh which gives the most complete bridging of the openings and makes a better traction surface.

And now, in addition to the familiar PANELED type, you can have "IRVING" FLOORING in CONTINUOUS type with an absolutely unbroken surface achieved by bolted, lapped, staggered joints.

Ask for Bulletin H-15

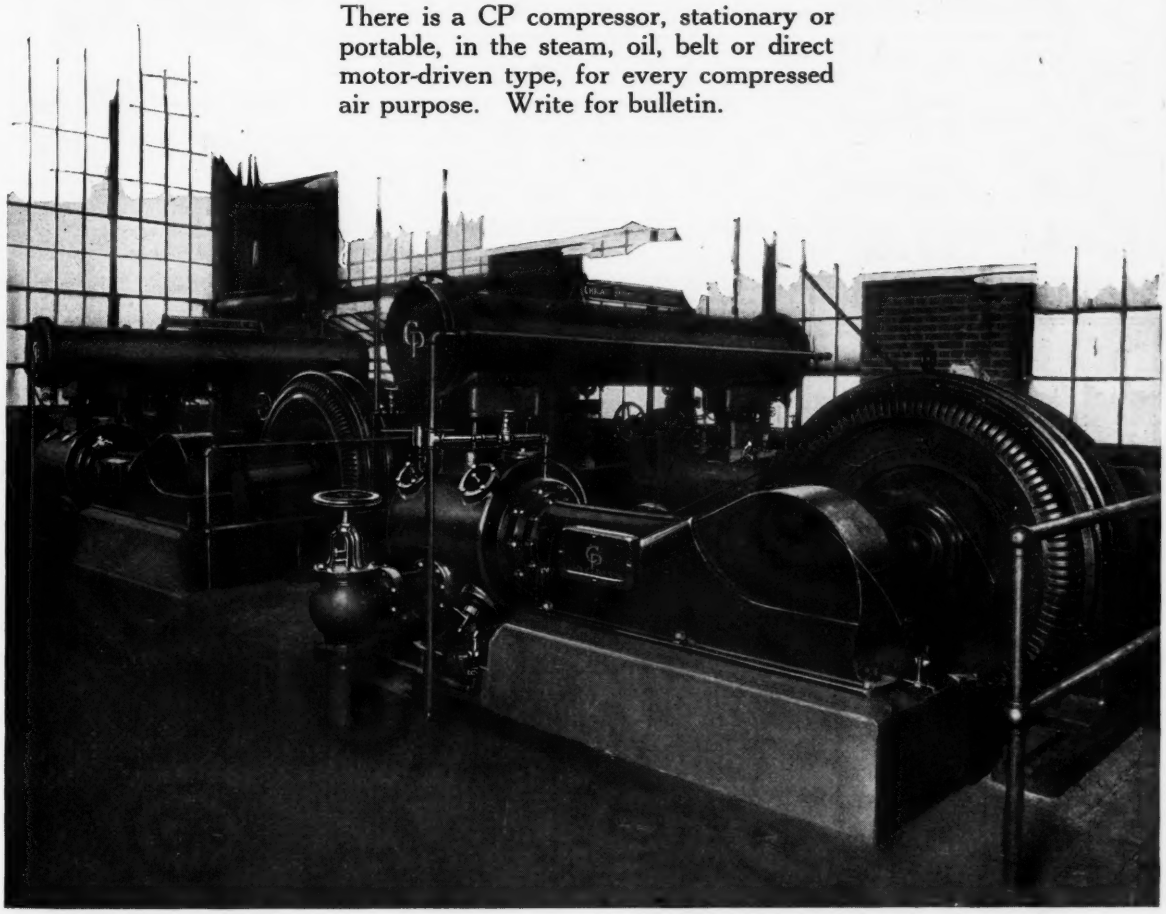
IRVING IRON WORKS CO.
LONG ISLAND CITY, N.Y. U.S.A.
Established 1902

P-115

CP COMPRESSORS *meet exacting demands*

THESE CP direct-connected synchronous motor-driven compressors, installed in a large steel foundry, are, like thousands of other CP installations, performing to their owner's complete satisfaction. They deliver compressed air reliably and with utmost economy because they are scientifically designed and equipped with the famous CP Simplate valves of large area, small clearance and long life; large bearings, easily adjusted; and automatic step capacity regulation with which power consumption is kept low, operation cool and pressure regulation close.

There is a CP compressor, stationary or portable, in the steam, oil, belt or direct motor-driven type, for every compressed air purpose. Write for bulletin.



Chicago Pneumatic Tool Co.

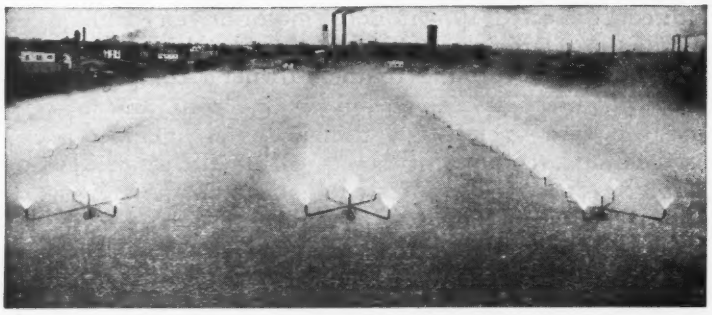
Sales and Service Branches all over the world

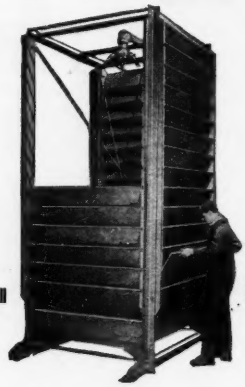
6 East 44th Street, New York, N. Y.

C-269

BINKS WATER COOLING EQUIPMENT

A Complete Water Cooling Service





Unit Type Spray Tower

for Diesel Engines, Compressors, Small Refrigeration Plants, etc. Capacity up to 100 gallons per minute. Saves space, saves water. Low in cost, economical to run.

Making good everywhere.

Write for Bulletin 4-E

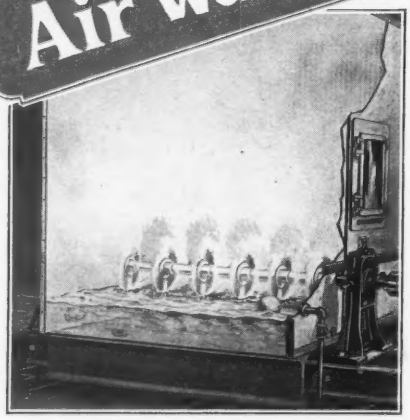
Spray Ponds for Any Capacity Completely Designed and Furnished

Performance of every Binks installation is fully guaranteed. Over 2500 plants are now Binks equipped. Low first cost, economical operation, and low maintenance costs are features that are rapidly standardizing Binks Cooling Systems throughout industry. Binks Spray Nozzles have earned a high standing for dependable, non-clogging service with low operating pressure. They merit your earnest consideration. Binks engineers design the complete system including everything above the Pond. Write for details.

BINKS SPRAY EQUIPMENT CO.

3130 Carroll Ave. Chicago, U. S. A.

NICHOLS Air Washers



Consulting Engineers Endorse These Major Advantages—

The complete elimination of spray nozzles with all their expensive equipage, costly maintenance and constant troubles from clogging.

Lowered installation and operating cost due to simplified construction and design of the Nichols Wobble Wheels.

Thorough efficiency in perfectly washing air and without requiring the constant attention usually necessary with other types of washers.

Our Engineering Department Will Gladly Furnish Detailed Information. Consulting Them Puts You Under No Obligation.

Spray Booths
Lumber Dryers
Veneer Dryers

NICHOLS PRODUCTS CORPORATION

NICHOLS-McCANN-HARRISON-SYSTEMS
DIRECT FIRED | OIL & GAS HEATERS

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Varnish Drying
Lacquer Drying
Air Washers

"We Keep Others in Hot Water"

B-H Type Storage Heater for live or exhaust steam.

Also Open and Closed Type Feed Water Heaters

Write for bulletin.

The SIMS Co., 2001 Holland St. ERIE, PA.

COCHRANE
Steam and Oil
SEPARATORS

Cochrane Separators are made in all sizes and for vertical, horizontal and angle pipes. Cochrane Receiver Steam Separators store steam close to the throttle, equalizing the flow through the steam lines and raising the average pressure in the steam chest.

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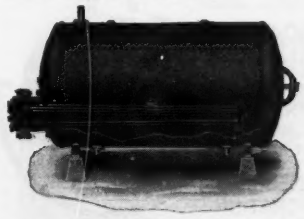
Patterson Hot Water Service and Storage Heaters are **guaranteed** to supply all the hot water required, as hot as required and as quickly as required. Operated by exhaust or live steam. Thousands in use. Backed by 48 years' experience. Made for any service, in any size.

Write for Catalog
The Patterson-Kelley Co.
Architects Building, New York

ALBERGER BUFFALO HEATERS

are built for a great variety of standard and special operating conditions for heating water with steam or for the interchange of heat from one liquid to another.



Instantaneous Heaters
Storage Heaters
Swimming Pool Heaters
Economizers
Coolers
Heat Interchangers

ALBERGER HEATER CO.
HOWARD IRON WORKS
285 Chicago St.
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NATIONAL
Heat Exchange Apparatus
made in
COIL TYPE
U TUBE
STRAIGHT TUBE

is adapted to hundreds of uses in process industries. Especially in the National coil type Feed Water Heater, the assurance of continued high efficiency over a period of many years makes the investment in a National both safe and attractive. If you demand the most dependable equipment, you will find National equals or exceeds specifications. Nation wide service has proved its reliability. Let us quote on your next installation.

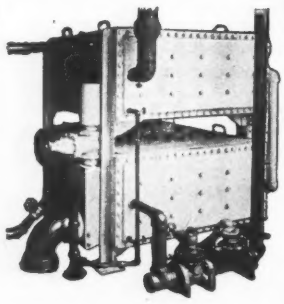
National Coil Type Feed Water Heaters give even distribution of water to the tubes.

Tube ends are readily accessible through plugged holes in the top of the tube chambers or by removal of the bolts in the larger type of heater.

Every National Installation individually engineered.

THE NATIONAL PIPE BENDING CO.
Est. 1883
160 River St., New Haven, Conn.
BOSTON NEW YORK PHILADELPHIA

GRADON LAUNDRY PREHEATER



Gradon Water Preheater

recovers heat from waste wash water—sets on floor.

HEAT EXCHANGE EQUIPMENT

EXPANSION JOINTS

SEPARATORS

Small—Compact—Clean—Efficient.

Write for our "Payment from Savings" plan.

Gradon engineering service is available through Gradon representatives in all principal cities.

GRADON MANUFACTURING COMPANY

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PHILADELPHIA, U. S. A.

Mechanical Draft Equipment

Used by a majority of the leading central stations.

Buffalo Forge Co.

188 Mortimer St., Buffalo, N. Y.

1878 Buffalo 1928 — "Air Engineers for Fifty Years"

OPERATE FEWER BOILERS

The additional steam output given by Wing Blowers usually allows a spare reserve boiler, for cleaning and repairing. Wing Blowers are easily and quickly installed in the boiler wall. Find out how little they cost!

Wing Blowers

Ask for Bulletin 87

L. J. Wing Mfg Co.
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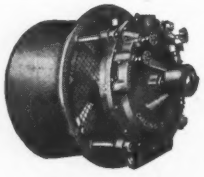
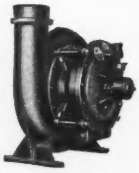
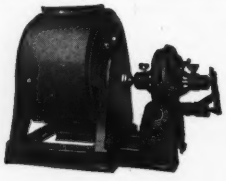
New York, N.Y.



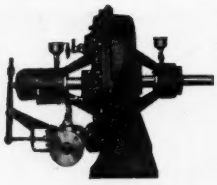
Turbine Propeller Blower



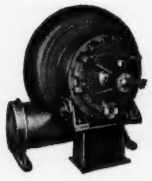
Up Blast Volume Blower



Stoker Fan



Steam Turbine



Turbine Pressure Blower

ALL CARLING TURBINES AND TURBINE BLOWERS PROTECTED BY PATENTED SAFETY DEVICE WHICH PREVENTS RUN-AWAY. FURTHER DETAILS ON REQUEST

CARLING TURBINE BLOWER CO. WORCESTER, MASS.

Represented in Canada by Mason Regulator Co. of Canada, Ltd., 314 Notre Dame St., West, Montreal, Quebec

An Irresistible Suction!

IDEAL

IDEAL Portable Vacuum Cleaner has a 210-mile-a-minute suction. Cleans motors, machinery and shop equipment faster and better.
Don't blow the dust and dirt from one machine to another. Remove them with Ideal Portable Vacuum Cleaner.

5 Day Free Trial

Ideal Commutator Dresser Co., 1033 Park Ave., Sycamore, Ill. 1228

Please send me an Ideal Portable Electric Machine on 5-days' free trial. (Specify voltage required.)

Name..... Position.....

Address .....

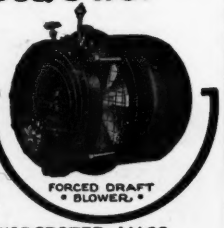
City..... State.....

Try it five days FREE, and see the difference in the cleanliness and operation of your machinery.

Specify voltage required.

Increased Boiler Rating With Low Priced Fuel

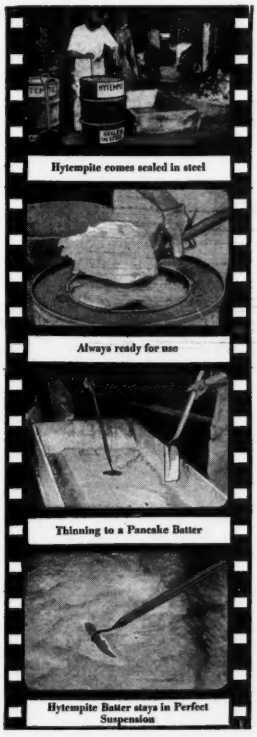
A result of Coppus Forced Draft Blowers



DO NOT CHANGE YOUR CHIMNEY OR PUT IN ANOTHER BOILER BEFORE READING BOOKLET NO. 145.

REGISTERED COPPUS U.S. PAT. OFFICE ENGINEERING CORPORATION
340 PARK AVE. WORCESTER, MASS.

CENTRIFUGAL TURBO BOILER FEED PUMPS • STEAM TURBINES • MINE VENTILATING BLOWERS


Hytempite comes sealed in steel
Always ready for use
Thinning to a Pancake Batter
Hytempite Batter stays in Perfect Suspension

Reduce Costly Repairs and Shutdowns with

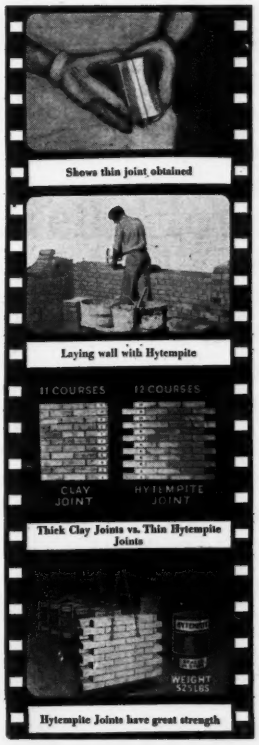
HYTEMPITE

(Reg. U. S. Pat. Off.)
"The Universal High Temperature Cement"

HYTEMPITE is universally used because it

—is easy to use
—makes a thin joint
—permits hot patching
—comes sealed in steel
—insures reduction of heat losses
—reduces amount of fuel consumed
—makes a tough bond throughout the wall
—resists destruction from constant vibration
—expedites repairs—prevents long shutdowns
—eliminates the possibility of shrinkage cracks
—allows furnace operation at high temperatures
—makes a perfect seal—prevents filtration of air
—air sets and does not depend on heat for strength
—retains strength at temperatures at which fire brick fail
—can be shot in place with a Quigley Refractory Gun
—is ideal refractory, used with crushed old fire brick

Let us help solve your furnace problems. Write to us.



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Stock and service in over 100 important industrial centers throughout the world

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Prevent penetration of slag - Resist wear by abrasion

Two excellent reasons why your boiler furnace linings should be protected against rapid deterioration at the fuel bed line with

CRYSTOLON BRICK
(Silicon Carbide)

A product of the electric furnace—molded into uniformly dimensioned, square cornered standard size brick of extreme hardness and load bearing strength.

The dense structure will not permit molten slag to penetrate, thus preventing clinker adhesion.

Crystolon Brick do not spall, crack or shrink perceptibly at high temperatures. Their use where wear is greatest will greatly extend the life of your entire furnace linings.

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It is a piece of corrugated sheet metal, 3 ft. long and 0.0126 in. thick.

It is a BECO sheet metal separator used in the

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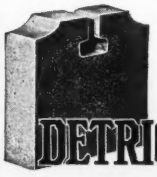

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Prolong the life of furnace linings with the

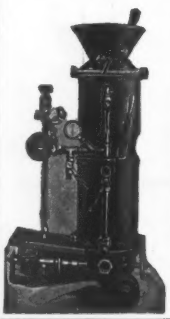
The quick and inexpensive way—

CEMENT-GUN
TRADE MARK

Only Machine that Handles Materials in a Dry State

Patch the spalled and eroded place of your furnace linings with a mixture of crushed fire brick, fire clay and water or whatever mixture you prefer with the "Cement-Gun."

No drying out necessary. Furnace can be used as soon as the job is finished and the repair work will last much longer because of the high pressure application made possible only by the "Cement-Gun."



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Please send us new, 6 by 9-in. illustrated bulletin 139-A, just off press, showing the many uses of the "Cement-Gun" around the boiler plant.

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Thermix Air Heater. Plate type; for recovery of heat from flue gas to heat air for preheating or industrial purposes. Write for Catalog 12-T.

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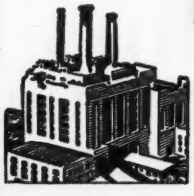

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For stacks, breechings, boiler fronts, pipes, air ducts, fans, cooling towers, etc. Heat resisting, high gloss, quick drying.

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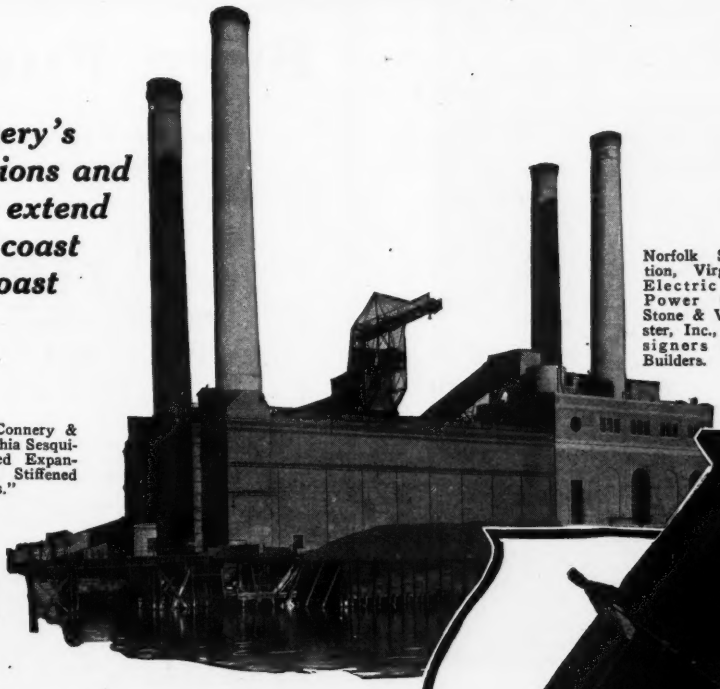
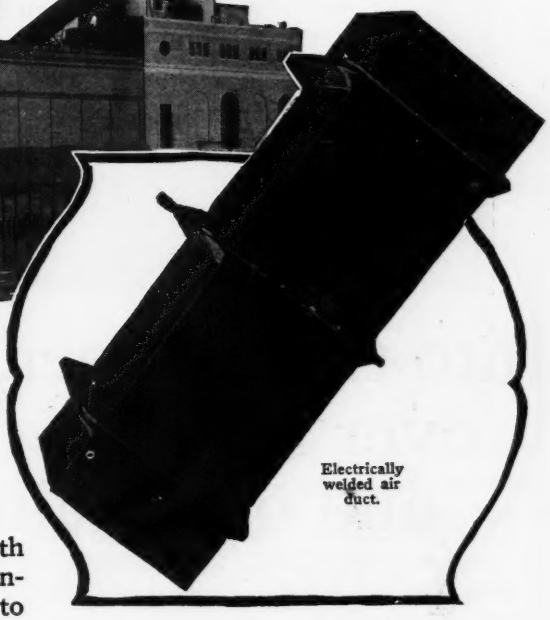
Connery's Installations and Service extend from coast to coast



Norfolk Station, Virginia Electric & Power Co., Stone & Webster, Inc., Designers and Builders.

Gold Medal awarded to Connery & Company at the Philadelphia Sesqui-Centennial "For Improved Expansion, Compensating and Stiffened Draft Flues and Dampers."

Virginia, too employs CONNERY CONSTRUCTION

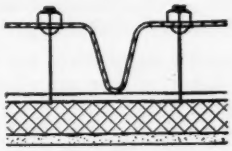


Electrically welded air duct.

More than a million horsepower equipped with Connery's Improved Expansion Stiffener Construction, installed from one end of the country to the other, is verification of the approval which leading engineers give to this improvement for power plants.

This modern construction provides for maximum contraction and expansion without the troublesome sliding joints and it will not buckle, warp or collapse. Having every corner and lap electrically welded, it is positively gas-tight and moisture-proof.

Not only for boiler breechings, but for uptakes, air ducts and preheater ducts as well, Connery's Improved Expansion Stiffener Construction is giving excellent results in all types of power plants. Consult with our engineers. Write.



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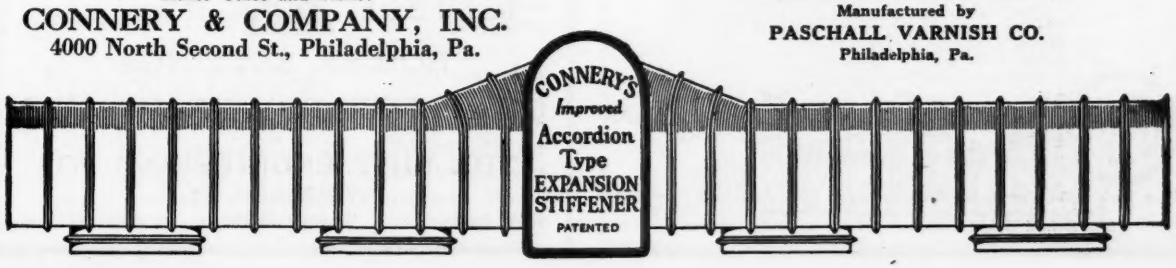

Into the dumper, over it goes— and out again!

THAT'S the way the W-S-M Revolving Car Dumper handles cars on scores of installations, including many of the most modern central stations and industrial plants.

Two or three minutes against hours by shoveling; a fraction of a cent per ton against many cents by other methods—no tie-ups of cars, fuel supply, or money with the W-S-M method.

Of course, each W-S-M installation pays for itself—in some plants in a year's time—and they go on paying year after year for many years.

That's because they are built up to the W-S-M standard—to give never-failing service for the longest possible time and at the least cost of operation.

Why not let our experienced engineers study your coal handling problems? Even the smaller plant cannot overlook W-S-M economy. Write for bulletin and consult us freely.

WELLMAN-SEAVER-MORGAN CO.
ENGINEERS CONSTRUCTORS MANUFACTURERS
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Burn Fuel Oil

For Economy, Flexibility and Increased Steam Output

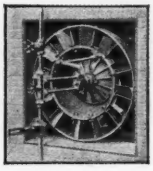
Many industrial plants have increased the capacity of their boilers and have reduced their steam cost by installing the

Enco

S. A. R. System for Burning Fuel Oil

The combination of steam atomization and correctly designed air register results in the maximum safety, high overall economy, and a very wide range in capacity, without changing the burner.

Both the fuel oil and the air are easily adjustable to carry the correct ratio and proper mixture of the two, continuously, at all boiler loads. The adjustments permit the flame to be shaped to conform to the furnace conditions.



Enco Systems for Burning Fuel Oil may contain either steam or mechanical atomizing burners, and either natural or forced draft air registers. Consult our engineering department on your particular requirements.

WRITE FOR BULLETIN OB-27
The Engineer Company, 17 Battery Pl., New York

Wiederholdt Chimneys are the best for Severe Service

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Let us remove your chimney troubles. Write for catalogues and estimates.

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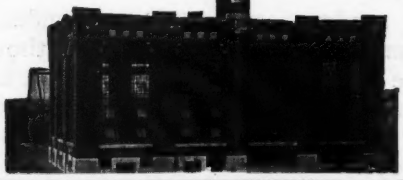

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Perforated Radial Brick — Reinforced Concrete

BOILER SETTINGS
COMPLETE POWER PLANTS

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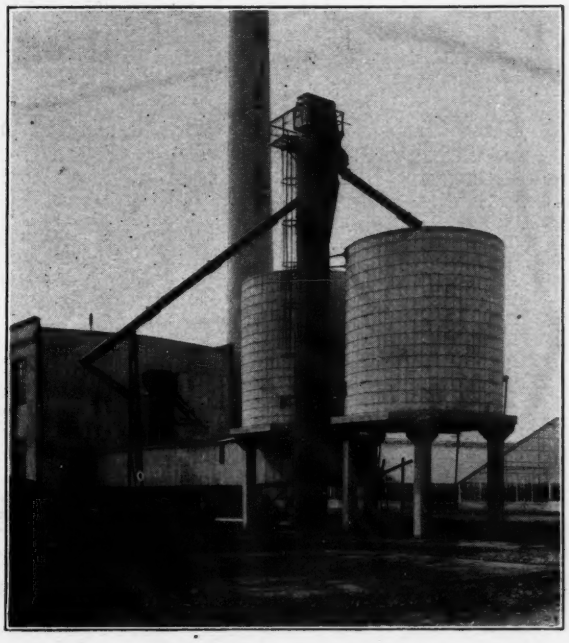

Complete and Compact Coal Handling Equipment installed at Rose Gardens of Joseph H. Hill Co., Richmond, Indiana

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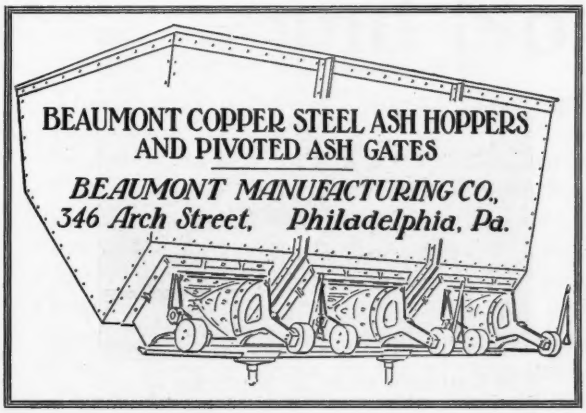

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"PENNSYLVANIA" *STEELBUILT*

COAL BREAKERS AND CLEANERS (Bradford Type)

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"Pennsylvania *STEELBUILT* Coal Preparation Machinery offers engineers and operators a wide selection of types and sizes, specialized for heavy, continuous service in Central Stations, Gas Works and Industrial Power Plants.

POSITIVE TRAMP IRON PROTECTION

UNBREAKABLE STEEL CONSTRUCTION

Put your coal preparation problems up to us

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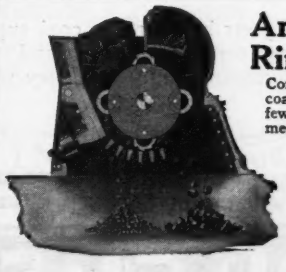
FOR all power plant and industrial requirements.

Designed and erected by men of 30 years' experience.

Let us solve your chimney problems. No obligation for sketch and cost estimate. Write for new catalog.



An IMPROVED Ring Coal Crusher

Combines more uniformly crushed coal, small power consumption and few repairs with patented adjustments to take up wear, patented metal trap and split cover for quick adjustments and repairs. Eight sizes.

Williams Patent Crusher & Pulverizer Co.

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ORIGINAL PATENTEES AND WORLD'S LARGEST BUILDERS OF HAMMERMILLS

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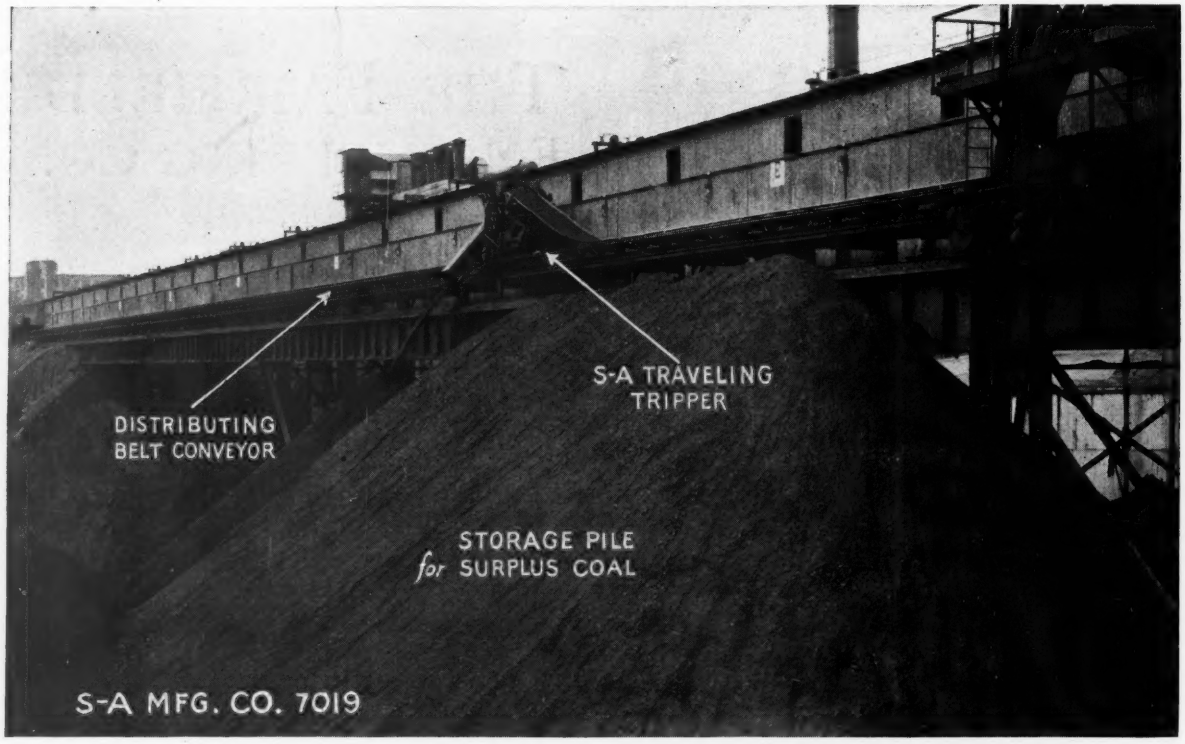


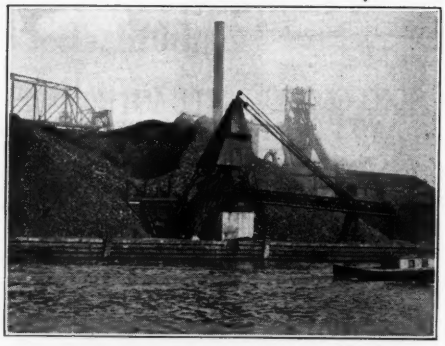
S-A COAL STORAGE SYSTEMS

S-A Coal Handling Machinery for Surplus Storage

When you cannot store all the coal in boiler room bunkers, the outside pile will serve as the reserve. Surplus fuel stored in great quantities requires handling and reclaiming at low cost per ton.

Coal handling equipments are necessarily designed to conform to the individual service required and the layout is generally influenced by the shape of the available property and the distance to be traversed.

An S-A Engineer will gladly submit ideas or a plan to provide your plant with surplus coal storage facilities.



The illustration shows an installation of S-A Machinery where coal is received and delivered by water or by rail.

If your boiler room coal supply is insufficient and you find a need for more coal on hand for emergencies, write to Stephens-Adamson Mfg. Co. They will have an idea for you.

DESIGNERS AND BUILDERS OF LABOR SAVING MATERIAL HANDLING MACHINERY

STEPHENS-ADAMSON MFG. CO. Main Offices, Aurora, Ill.
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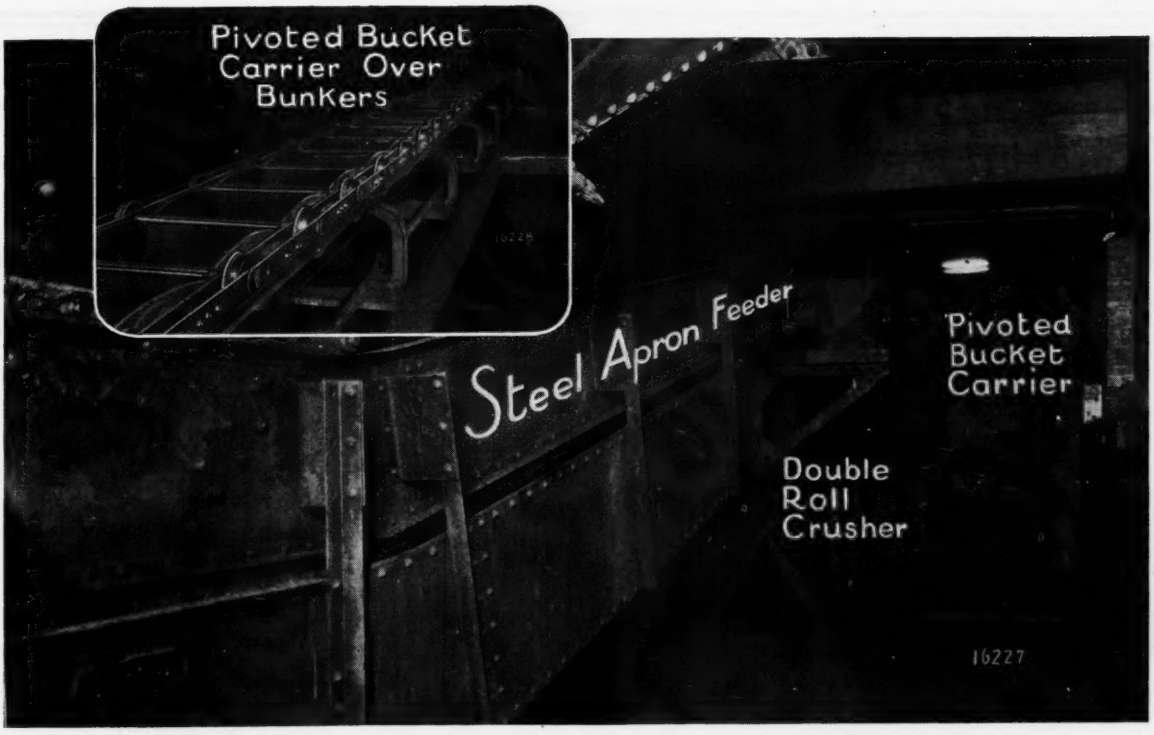

Four Years' Service and No Repairs

This Jeffrey Coal and Ashes Handling Equipment has kept the bunkers over the boilers filled for four years at the Crane Company of Chicago, and according to the statement of their power plant engineer, has needed practically no repairs. It was installed in December, 1924, to meet increased power requirements.

Hopper bottom cars dump the coal into the Track Hopper shown in the photograph. The Steel Apron Feeder carries the coal to the Double Roll Crusher at the rate of 85 tons an hour. Underneath the Crusher the Pivoted Bucket Carrier lifts the coal above the bunkers and distributes it over a 260-ft. horizontal run. Ashes are carried out on the lower run of the Pivoted Bucket Carrier.

This installation illustrates only one of the many Jeffrey methods of handling coal and ashes. We will be glad to send a complete description of equipment to meet your requirements.

The Jeffrey Manufacturing Company

905-99 North Fourth St., Columbus, Ohio

New York, Buffalo, Utica, Rochester, N. Y., Philadelphia, Pittsburgh, Scranton, Pa., Boston, Cincinnati, Cleveland, Detroit, Chicago, Montreal, Charleston, W. Va., Milwaukee, St. Louis, Denver, Salt Lake City, Atlanta, Birmingham, Houston

51 YEARS OF SERVICE TO INDUSTRY

JEFFREY

MATERIAL HANDLING EQUIPMENT

Jeffrey Products

Elevators—Conveyors
Portable Loaders
Coal and Ashes Handling Equipment
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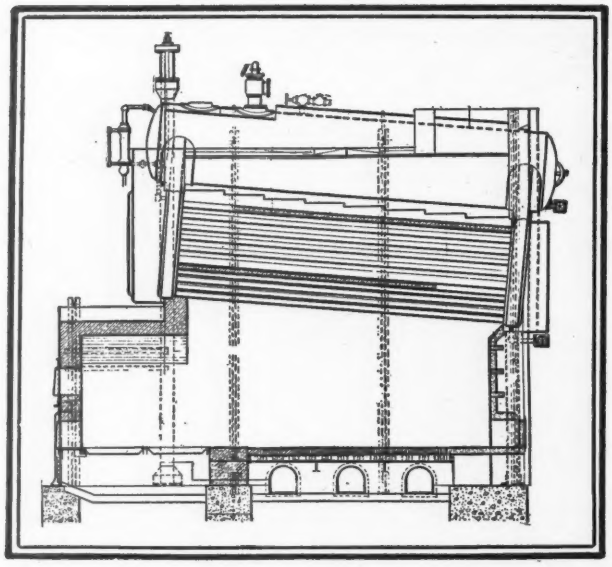
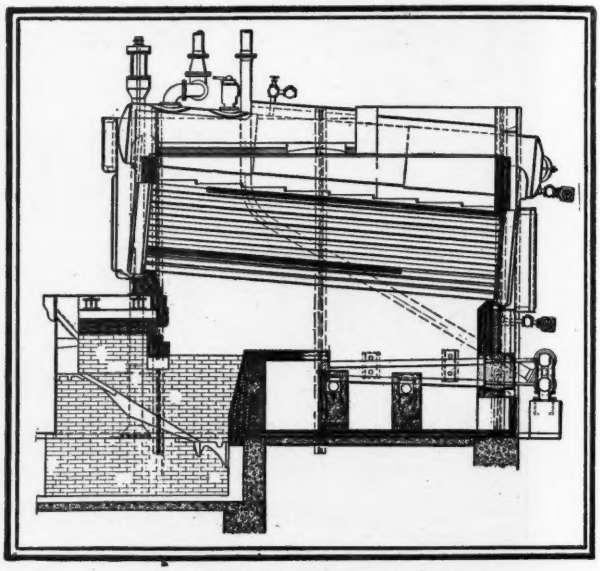
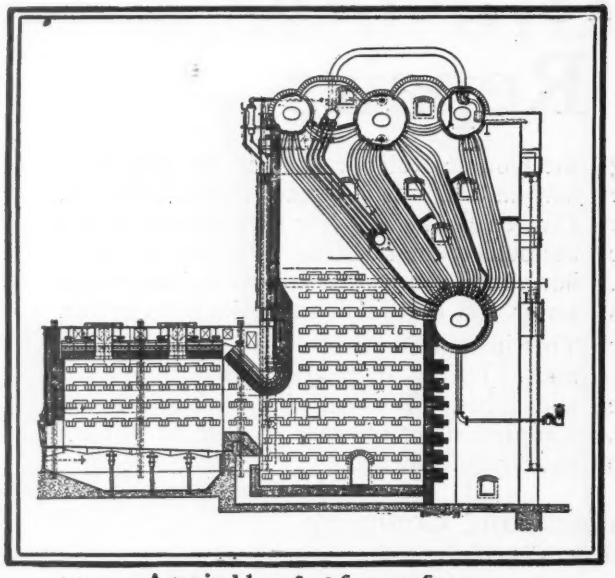


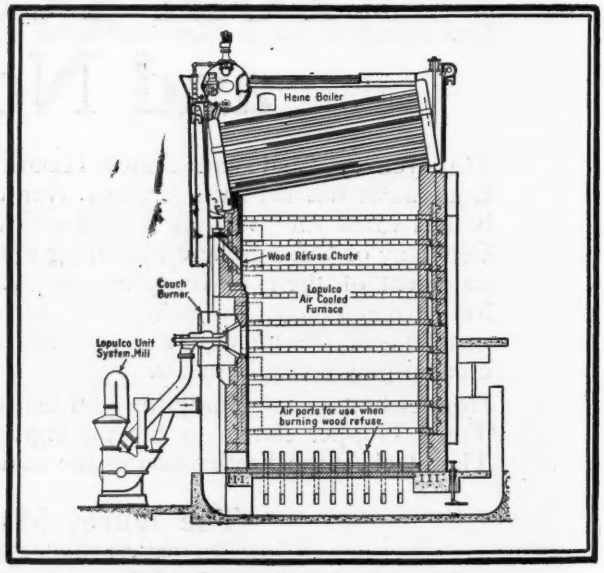
A furnace which permits the burning of long timbers as well as smaller pieces.



An installation in a furniture factory where the waste wood is all dry shavings and sawdust.



A typical hog fuel furnace for a V-Type boiler.



A Good example of a furnace for burning dry wood refuse and pulverized fuel.

COMBUSTION

USING *Wood Refuse* FOR FUEL

WOOD refuse is available for fuel in many industrial plants using wood working machinery, and, throughout the lumber industry.

A recent issue of "The Safety Valve" issued by this organization, is devoted to the efficient utilization of various forms of wood refuse.

Successful settings for burning wood refuse either alone, or, in combination with other fuels are illustrated and described. Copies of this edition will be sent upon request.

Combustion Engineering Corporation by reason of the diversity of products offered, and the experiences gained in their development and application, is in a position to analyze any fuel burning or steam generating problem and suggest the equipment properly adapted to plant and fuel conditions.

"It pays when the pressure is high enough"
The Safety Valve
Burning Wood Refuse for Fuel

Copies of "The Safety Valve" will be sent to those interested in using wood refuse for fuel.

Combustion Engineering Corporation

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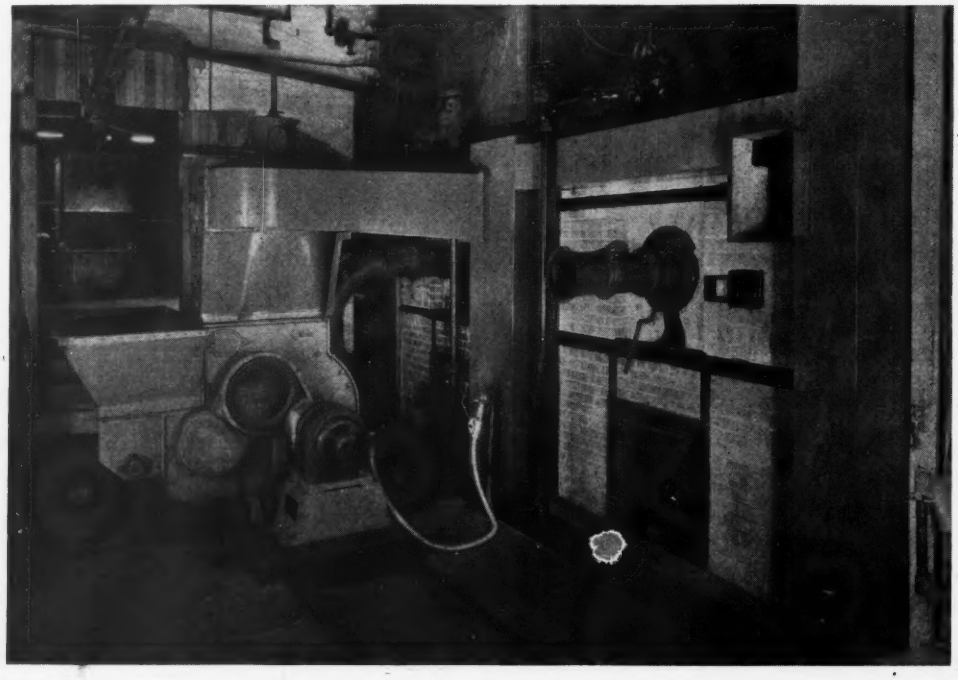

Portable Pulverizers For the Small Boiler Plant

If you have a standby it is not necessary to install a pulverizer for each boiler.

The UNIPULVO readily lends itself to the portable plan so that it can be moved from boiler to boiler. Why tie up capital in idle equipment?

Learn to burn—the UNIPULVO way!

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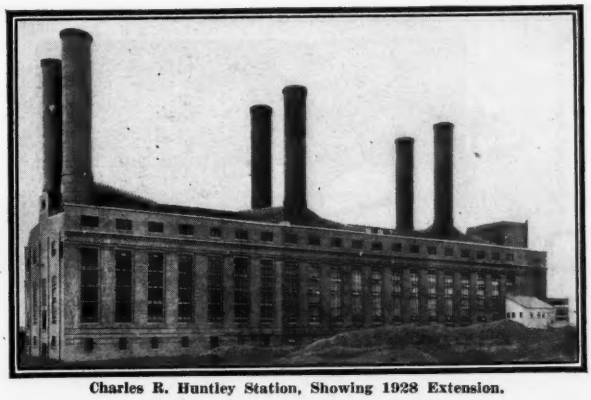
UNIT PULVERIZER



Charles R. Huntley Station, Showing 1928 Extension.

New Pulverized-Coal Fired Boilers at "Buffalo"

First unit placed in service met three-hour emergency demand for 200,000 lb. of steam per hour (493% of rating) when lighted for first time

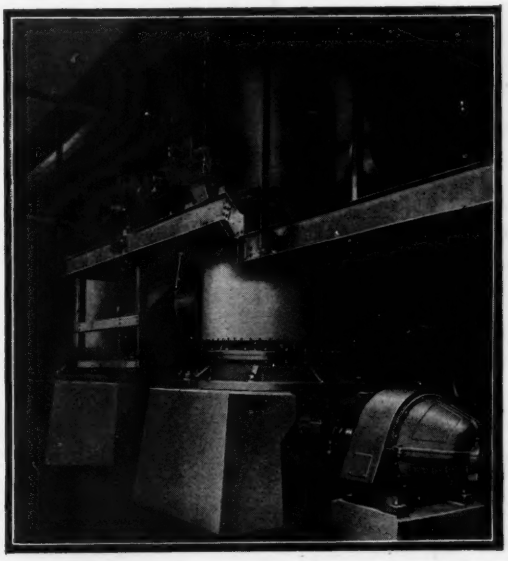
The first boiler of the new extension of the Charles R. Huntley Station of the Buffalo General Electric Company, Buffalo, N. Y., was fired for the first time on September 25, 1928.

In 35 minutes it was on the line carrying an emergency demand for 200,000 pounds of steam per hour (493 per cent of rating). This it continued to do for three hours. On the following day the unit carried the same load for 7½ hours. Since then it has been regularly used to help meet the varying load demands upon this station.

The fact that it was possible to put this unit into service immediately after being first lighted and to keep it in regular service is evidence of the engineering skill and care that attended its manufacture and erection.

The unit is one of four Babcock & Wilcox boilers, each of 13,810 sq. ft. of heating surface, that are being installed in this station, which is part of the Buffalo, Niagara and Eastern Power Corporation's hydro-electric system. The steam plant is used for emergency stand-by service and to carry the base load when system conditions demand. Each boiler unit has a complete Fuller Lehigh, Bailey Water-Cooled Furnace of the slag-tap type and is pulverized-coal fired by the Fuller Lehigh Direct-Fired System.

Liquid-ash removal which proved so successful in the initial Fuller Lehigh Equipped Installation is a feature of this new extension.



Fuller Lehigh Pulverizing Mills and Raw-Coal Feeders in 1928 Extension of Charles R. Huntley Station of the Buffalo General Electric Company. Total capacity of the four new units will be 1,200,000 lb. of steam per hr.

For further information on this extension and on the initial installation, write us

FL

for reprints, articles and other information relative to the Chas. R. Huntley Station.

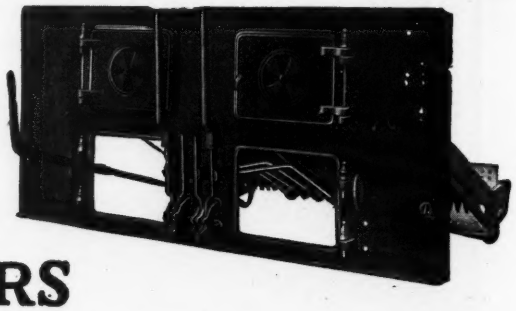
FULLER LEHIGH COMPANY, FULLERTON, PENNA. ~ *A Babcock & Wilcox Organization*

FULLER LEHIGH

PULVERIZED-COAL EQUIPMENT ~ WATER-COOLED FURNACE WALLS

Open your fire door only to put on coal when you have

KELLY IMPROVED HAND STOKERS



The outside levers on the Kelly Improved Hand Stokers are what save the boilers from those extreme fluctuations in temperature which are so destructive. Inrushes of cold air cause strains on the boiler, as well as waste of fuel.

Keep your fire doors closed during cleaning, rocking and dumping, and your fires will burn any kind of coal steadily and clean. Save 10 to 25 per cent on your fuel bills because only ash and clinkers reach the pit.

Take advantage of this great fuel economizer by investigating Kelly products now.

The four center levers operate the movable grate bars. Each one moves the alternate bars on one side of the grate. Dumping plates are dumped by manipulation of the levers found beside the ash doors. The handles of these come in two styles as shown in the illustration.

When you buy KELLY STOKERS-GRATES GOSHEN IND. *you buy results*

Specify Kelly for These Products

Improved Hand Stokers
Rocking and Dumping Grates — Style A and Style B
Portable Kiln Grates
Circle Grates
Grate Bars — all patterns
Boiler Fronts

The Kelly Foundry & Machine Co.
617 Ninth St., Goshen, Ind.
POWER PLANT ENGINEERS
Established 1887

NEW YORK OFFICE: 53 Park Place

CHICAGO OFFICE: 178 W. Adams St.

Gets more heat from a pound of coal than any other combustion system
Capacities up to 700,000 pounds of steam per hour

The TAYLOR UNIT and A-E-CO FURNACE ARMOR

AIR COAL Taylor Unit For lower power costs

A-E-CO

American Engineering Company, Philadelphia

Canadian sales and service by Affiliated Engineering Companies, Ltd., Southam Bldg., Montreal

DETROIT UNDERFEED STOKERS

Ask For Bulletin 879

Detroit Stoker Company
879 General Motors Bldg - Detroit.

HUBER STOKERS

Mechanical Stoker — Hand Stoker (heavy duty)
Semi-Mechanical Stoker — Hand Stoker

A Stoker for Every Boiler

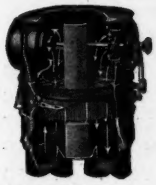
Send for a Copy of
"Five Minutes With the Coal Bill"

FLYNN & EMRICH COMPANY
307 North Holliday Street — Baltimore, Maryland

Ljungström AIR PREHEATER

Reg. U.S. Pat. Off.

CONTINUOUS REGENERATIVE COUNTERFLOW



FOR preheating combustion air with heat from the boiler flue gases. 10 to 15 per cent fuel saving. Better combustion from any fuel. 70 per cent heat recovery possible only with the continuous regenerative counterflow principle used exclusively in the Ljungström Air Preheater. *Write for literature.*

750,000 Boiler hp. in service

Air Preheater Corp., 25 Broadway, New York

The LACLEDE CHAIN GRATE STOKER

is the

DOMINANT STOKER

for the

HIGHER VOLATILE COALS

Write For Details

LACLEDE STOKER CO.

4438 Hunt Ave. St. Louis, Mo.

NEEMES GRATES

Neemes Improved Shaking and Dumping Grates have for 54 years been the choice of careful and discriminating buyers because any kind of coal can be burned on them with the best possible combustion.

NEEMES FOUNDRY, INC.
186 First Street Troy, N. Y.
Manufacturers of Round and Square Grates and Hand-Operated Stokers
Established 1874

ECONOMY QUALITY 1874 NEEMES SERVICE

Water Tube Boilers for Every Service

BOILERS of high quality for central stations and industrial plants of all sizes, and for utilization of waste heat from kilns and furnaces. Steel construction only. Straight tube and bent tube types. Noted for long life and economy of operation.

Engineering service available—wire or write.

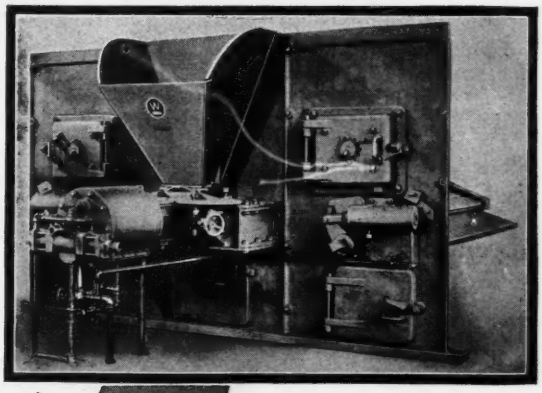
EDGE MOOR IRON COMPANY Edge Moor, Delaware

EDGE MOOR Water Tube BOILERS

FOR INCREASED FUEL ECONOMY

Stokers

WESTINGHOUSE ELECTRIC



Single Retort Underfeed Stoker

IN Westinghouse stokers, you find the same progressive engineering, sturdy construction and dependable performance that characterize all other well-known Westinghouse apparatus.

Forty years' experience with combustion problems places at your disposal an organization thoroughly prepared, and at all times ready to consult with you on any commercial coal burning problem.

Westinghouse Electric & Manufacturing Company
So. Philadelphia Works Philadelphia, Pa.
Sales Offices in All Principal Cities of the United States and Foreign Countries

Westinghouse

X98148

for each fuel—

Bituminous

If you are interested in obtaining power efficiently from Bituminous fuel at minimum of expense for up-keep, you will be interested in McClave Bituminous equipment. Each unit is specially designed for the purpose intended under all conditions and ratings.

For instance, the McClave 2-A Grate has long been recognized as standard equipment for burning bituminous and lignite fuels. The same is true of McClave Hand Fired Stokers. With the addition of the McClave Forced Draft and Natural Draft Chain Grate Stokers to this group, the McClave bituminous line of combustion equipment is complete.

McClave can serve you in the use of Bituminous or Lignite fuels. McClave service is unbiased as to fuel or unit for the needed combustion.

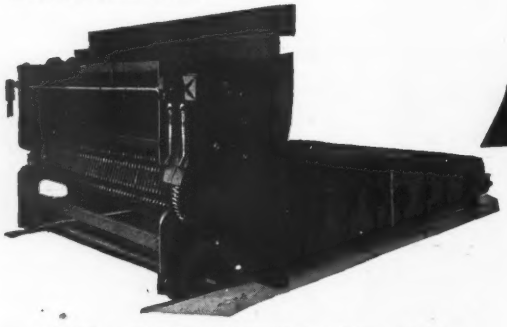
McClave GRATES AND STOKERS

Anthracite

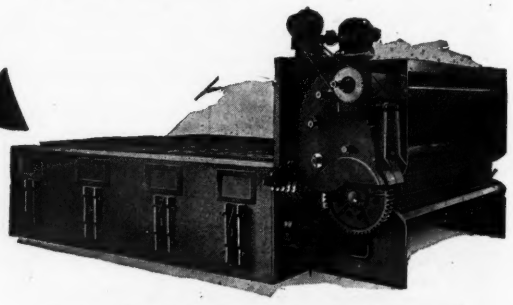
As a user of Anthracite fuel, you desire every ounce of energy obtainable in the production of power. This is possible by using McClave specially designed equipment for burning anthracite. Each McClave Anthracite unit is scientifically designed and built for the purpose of giving highest efficiencies through the control of air and fuel.

The McClave 4-A Grate was the pioneer dumping grate for burning Anthracite and is everywhere accepted as standard equipment in this field. The Type M-A Stoker was also the pioneer in this type of equipment for burning Anthracite. The new Forced Draft Chain Grate Stoker for Anthracite completes the McClave Anthracite line in a way that we believe cannot be matched today by any other manufacturer of combustion equipment.

McClave can serve your Anthracite requirements with unbiased engineering data as to grade of fuel or unit best suited to your requirements.



McClave Chain Grate Bituminous Stoker (Forced Draft or Natural Draft) for all grades of bituminous fuels.



McClave Forced Draft Chain Grate Stoker for all grades of Anthracite, Coke Breeze and Mixtures.

McCLAVE-BROOKS COMPANY

Sole Makers of McClave Grates Since 1883

SCRANTON, PENNSYLVANIA

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ATLANTA, 1328 Candler Bldg.
DALLAS, TEXAS, 1204 Santa Fe Bldg.

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MONTREAL, QUEBEC, c/o Heating Equipment Co., Ltd., 1131 Bleury St.
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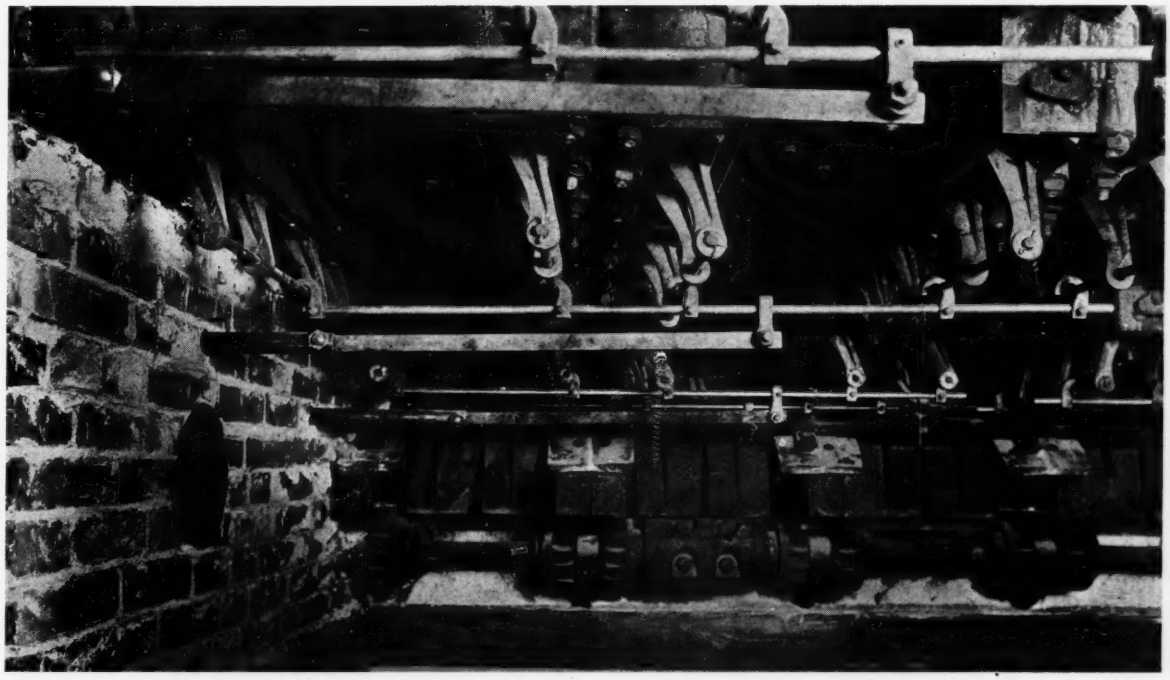
McClave COMBUSTION SYSTEMS FOR HIGHEST ECONOMY AND EFFICIENCY IN BURNING *Anthracite, Bituminous, Lignite*

McClave STOKERS AND GRATES

"FIT THE STOKER TO THE COAL"

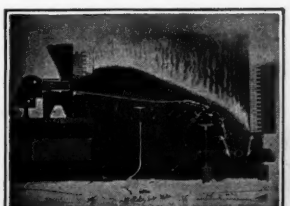
Air to Every Part of Stoker Under Control

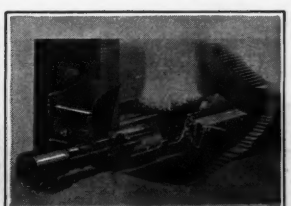


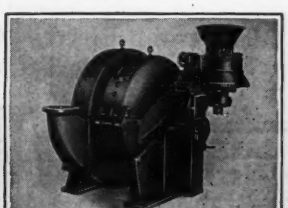
Photograph Showing Damper Arrangement with Air-Zoned Super-Stoker

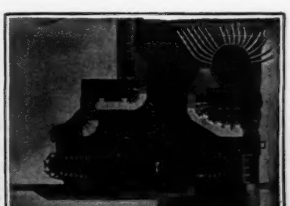
This photograph, taken from the front of the air chamber, shows how completely the air is controlled to every section of the new Riley Air-Zoned Super-Stoker. These dampers are only about seventeen inches long so that very close air regulation is possible throughout the entire length of the stoker. The dampers are operated by hand wheels located at the boiler side walls. Notice the simple rugged construction of the dampers and the operating mechanism. Nothing fancy or elaborated but a mechanism that will continue to function satisfactorily when age creeps in.

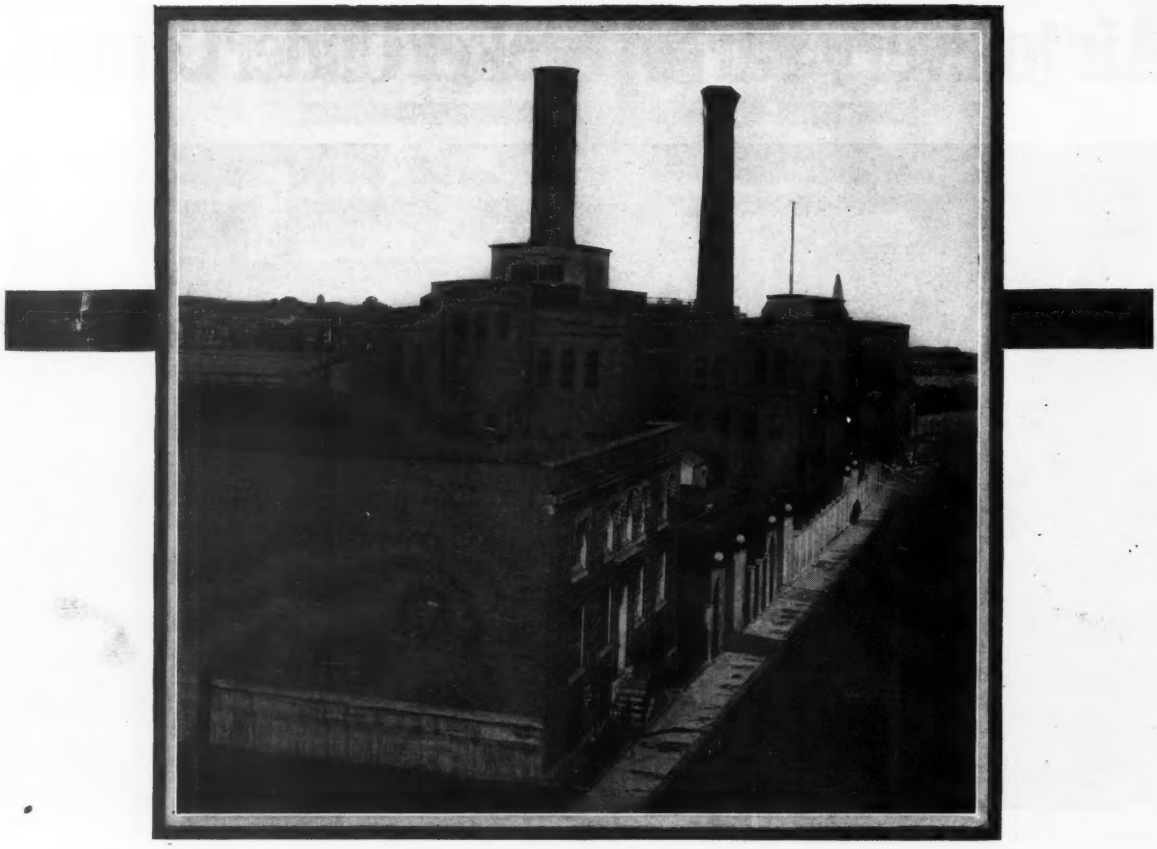
RILEY STOKER CORPORATION
9 Neponset Street, WORCESTER, MASS., U. S. A.
Riley Engineering & Supply Co., Ltd., Toronto, Canada


RILEY AIR-ZONED SUPER-STOKER


JONES UNDERFEED STOKERS


ATRITA UNIT PULVERIZER


HARRINGTON TRAVELING GRATE STOKERS



Plant of the Salem Electric Light Company, Salem, Mass. One of the plants under the management of Charles H. Tenney & Company, and in which Foster superheaters and water backs are installed.

Foster Superheaters
Charles H. Tenney

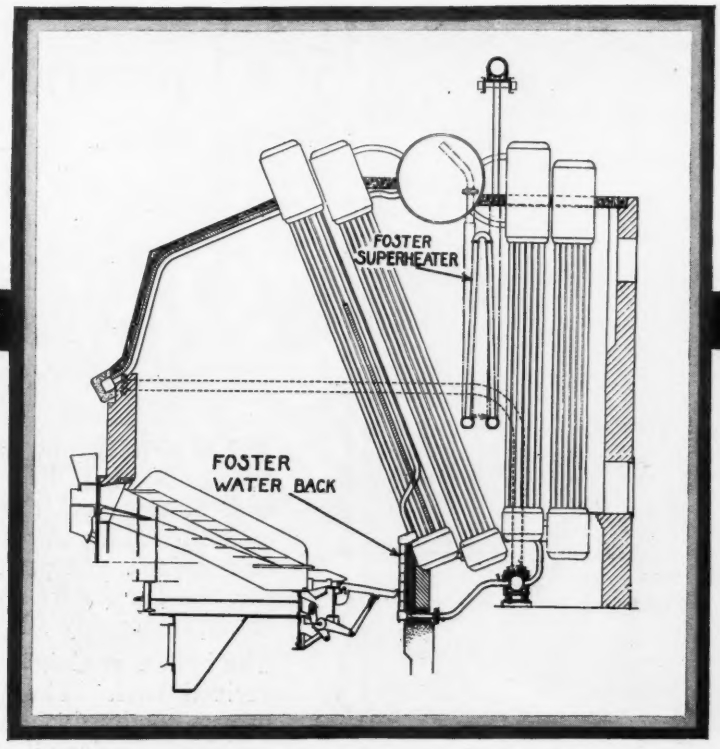
In five of the plants under the management of Charles H. Tenney & Company there are twenty-eight Foster superheaters, installed in water tube boilers aggregating 17,814 horsepower. These superheaters have been rendering efficient and reliable service covering a period of sixteen years. The maintenance cost of the superheaters during this time amounts to only $1.77 per superheater per year, or less than one-tenth of one per cent of the cost, per year of use. Over this long period only one element, out of a total of 892 elements, has been replaced.

The plants in which these installations were made include:—

Haverhill Electric Company
Salem Electric Light Company

AERO UNIT COAL PULVERIZERS
AIR HEATERS CENTRIFUGAL PUMPS
CONDENSERS COOLING TOWERS
ECONOMIZERS EVAPORATORS
EXPANSION JOINTS FEED WATER HEATERS

FOSTER



Cross section drawing of one of the 750 hp. Bigelow-Hornsby boilers at the Salem plant showing location of the Foster superheater and Foster water back.

in plants managed by and Company

Fitchburg Gas & Electric Company
Springfield Gas Light Company
Rockland Light & Power Company

The construction of the Foster superheater, consisting of seamless steel tubing, over which is shrunk a continuous cast iron extended surface, insures a high rate of heat absorption with maximum ruggedness in the elements.

FOSTER WHEELER CORPORATION

165 Broadway, New York, N. Y.

Branches in Principal Cities

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Foster Wheeler Limited; London, England.
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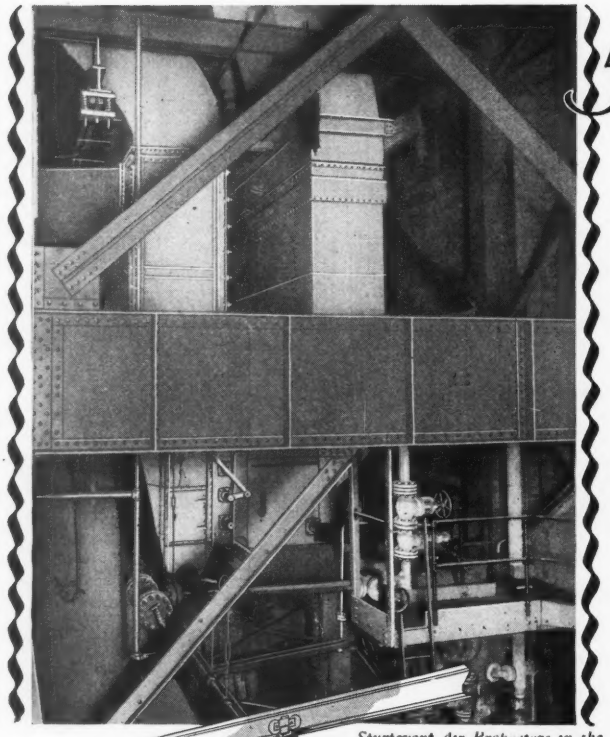
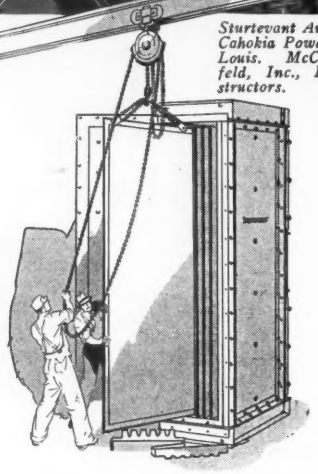
WHEELER

FRACTIONATING TOWERS HEAT EXCHANGERS
STEAM JET AIR PUMPS SUPERHEATERS
TUBE STILLS VACUUM PUMPS
WATER COOLED FURNACE SURFACES
BRASS AND COPPER TUBING AND PIPE



Sturtevant Air Preheaters in the Cahokia Power Station, East St. Louis. McClellan & Junkersfeld, Inc., Engineers & Constructors.



Each Sturtevant Air Preheater Chamber is removable and reversible.

500 pounds of coal saved per hour at peak loads *by* Sturtevant Air Preheaters *at Cahokia*

CAHOKIA power station, East St. Louis, has three boilers equipped with Sturtevant Air Preheaters. Records of the first nine months' operation show fine savings. At peak loads, for example, the Preheaters save coal at the rate of approximately 500 pounds per hour.

The boilers at Cahokia are fired by pulverized coal. The preheated air improves combustion and assures quicker ignition. Under all loads, coal is saved . . . at the peak, savings are exceptionally impressive.

And this worth while saving is not all that Sturtevant Preheaters contribute toward economy of operation. For their *exclusive* features of construction greatly reduce maintenance cost—and simplify inspection. Chambers are not welded together. Instead, they are in units that can readily be removed. With little effort any chamber can be slid out for inspection . . . reversed if corroded . . . then returned to its place again. Double life is therefore assured . . . and time and labor saved.

If you are not familiar with Sturtevant Air Preheater construction write our nearest office. It will gladly send you a copy of Bulletin No. 331, giving full details.

B. F. STURTEVANT COMPANY

Plants and Offices: Berkeley, Cal.; Camden, N. J.; Framingham, Mass.; Galt, Ontario; Hyde Park, Mass.; Sturtevant, Wis.

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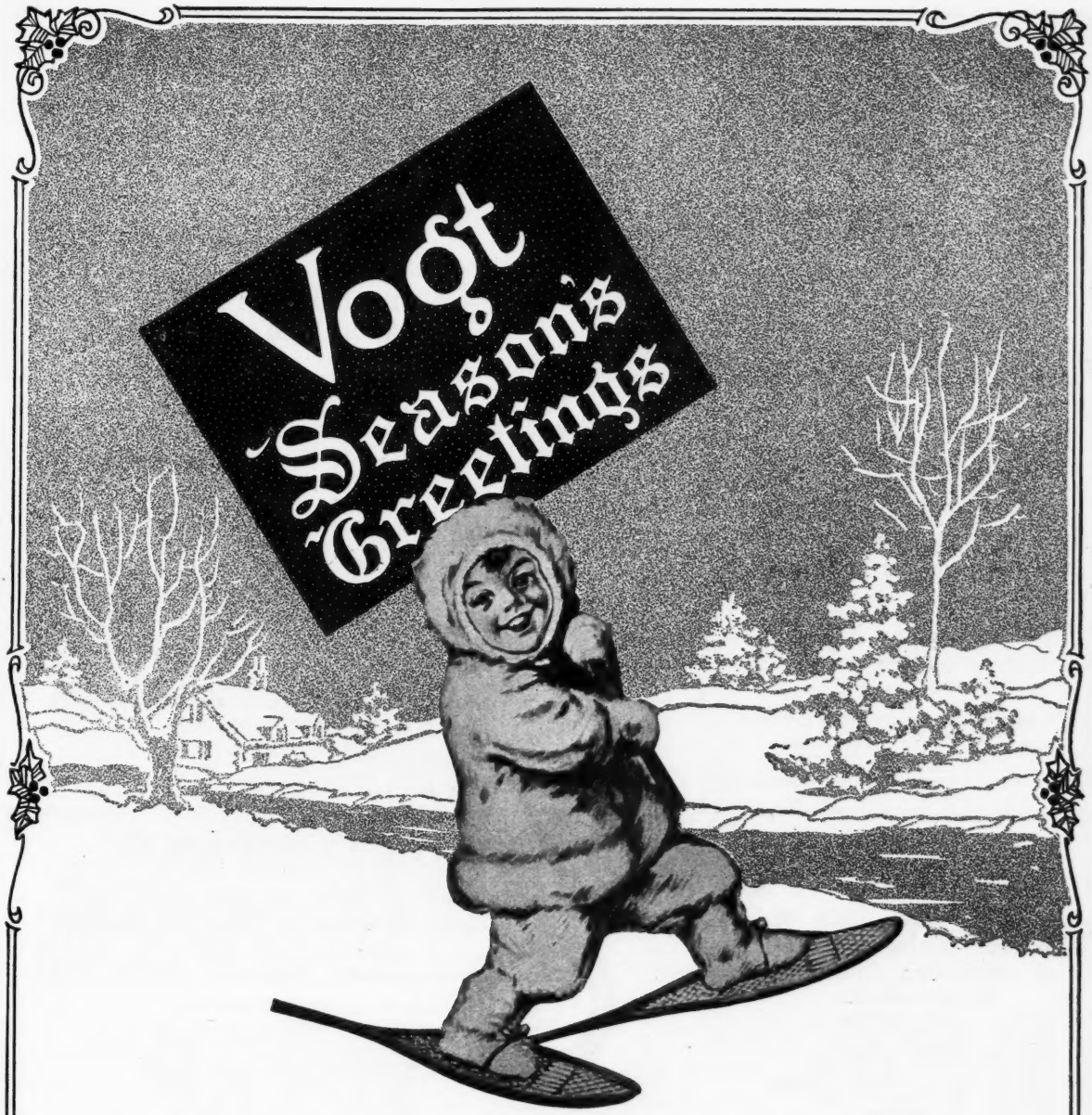
Sturtevant (REG. U. S. PAT. OFF.) *Air Preheaters*

STEAM TURBINES ~ FORCED AND INDUCED DRAFT FANS ~ ELECTRIC MOTORS
FUEL ECONOMIZERS ~ GENERATING SETS ~ AIR PREHEATERS

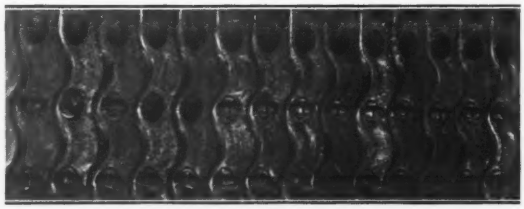


The Spirit Of The Season Prompts
Us To Express To You Our Best
Wishes For A Merry Christmas
And A Happy, Prosperous New Year

Henry Voqt Machine Co.
Louisville, Kentucky.

Forged Steel Sectional Headers

For Pressures up to 1600 lbs.



Our Forged Steel Headers are made from the highest grade seamless steel tubing and are available for any Working Pressure up to 1600 lbs. per sq. in.

The Hedges-Walsh-Weidner Co.
Chattanooga, Tenn.
A Subsidiary of
International Combustion Engineering Corporation
New York

SPRINGFIELD
BOILERS—WATER WALLS
SECTIONAL—ALL STEEL
ALL SIZES—ALL PRESSURES

Repeat orders constitute the largest part of our business

SPRINGFIELD BOILER CO.
SPRINGFIELD, ILLINOIS

Remarkable Efficiencies

Shown by

BADENHAUSEN (Patented)
Boilers
Preheaters
Superheaters
Water Cooled Furnace Walls

Each a unit in itself, yet an integral part of the boiler proper
Surveys and Tests by outside Engineers forwarded on request

BADENHAUSEN CORPORATION
General Office and Works
Cornwells Heights, Bucks County, Pa.

THE BABCOCK & WILCOX COMPANY
85 LIBERTY STREET, NEW YORK

Builders since 1868 of Water Tube Boilers of continuing reliability

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NEW ORLEANS, 344 Camp Street

Works:
Bayonne, N. J.
Barberton, Ohio

Makers of Steam Superheaters since 1898 and of Chain Grate Stokers since 1893

BRANCH OFFICES
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SALT LAKE CITY, Kearns Building
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SEATTLE, L. C. Smith Building
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HAVANA, CUBA, Calle de Aguiar 104
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TITUSVILLE
POWER AND HEATING BOILERS
FOR
ALL INDUSTRIAL PURPOSES

Write for Descriptive Literature

THE TITUSVILLE IRON WORKS COMPANY
TITUSVILLE PENNA.

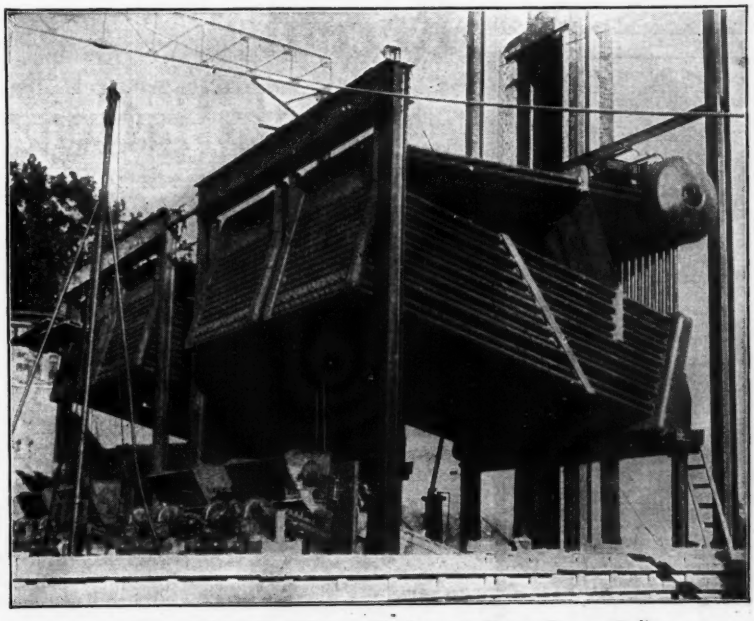
See Our Colored Insert in the NEXT ISSUE

Another ERIE CITY STEAM UNIT

HORIZONTAL CROSS DRUM BOILERS *for* INDUSTRIAL PLANTS

Horizontal Cross Drum Boilers during the past few years have been widely selected for the generation of steam in industrial plants. This trend has been due to the successful operation in both central station and industrial plants; improved water conditions; and the desirable characteristics of performance.

Boilers built in the Wickes shops are fabricated in accordance with the highest standards known in the boiler making art. Performance and low cost of maintenance have been proven with Wickes Units.



Four 507 H.P. Wickes Horizontal Cross Drum Boilers, Fox River Paper Co., Appleton, Wis.

1. **Established Water Level** —one level in one drum.
2. **Straight Tubes** — small stock of repair parts.
3. **High Ratings** — positive and rapid water circulation.
4. **Baffles** — vertical monolithic are tight.
5. **Economy**—High rate of heat absorption by radiation and convection.
6. **Wickes Patented Headers** —one seam to rivet and caulk.
7. **Wickes Workmanship**—all boilers drilled from solid plate — all rivets hydraulically machine driven.

Ten Users of Wickes H. C. D. Boilers

Kohler of Kohler	Morton Salt Co.
Riverside Fibre Co.	Berry Bros.
Dow Chemical Co.	Packard Motor Car Co.
General Motors Corp.	Belding-Hall Co.
Garlock Packing Co.	Thilmany Pulp & Paper Co.

Write for Bulletin No. 11—"What Boiler and Why"

THE WICKES BOILER CO.

Established 1856

Saginaw, Mich.

SALES OFFICES:

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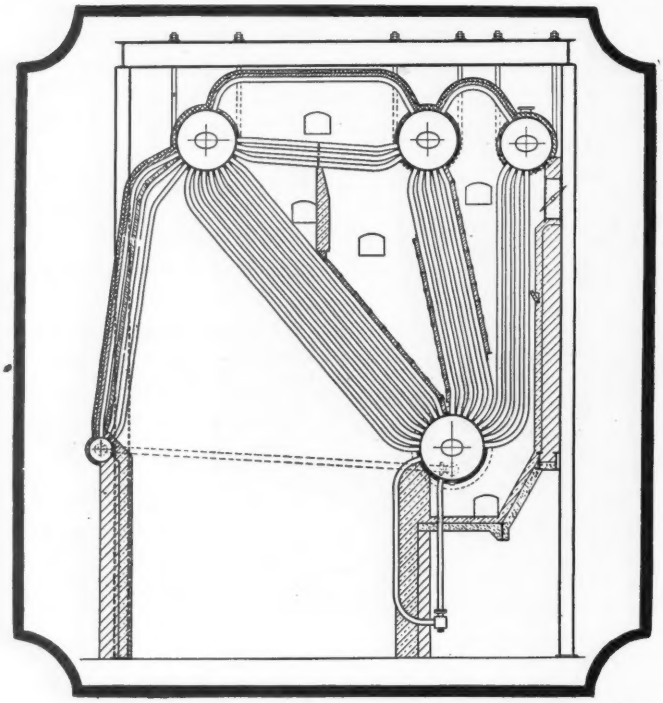
Pittsburgh, 1218 Empire Bldg. General Motors Bldg. Seattle, 736 Henry Bldg.

WICKES CROSS DRUM BOILERS

UNION Bent Tube BOILERS



Recent Installations

U. S. Rubber Reclaiming Co.---Buffalo, N.Y.
Otis Steel Company ---------Cleveland, Ohio
State School for the Blind --Columbus, Ohio
State School for the Deaf---Columbus, Ohio
H. F. Watson Company--------Chicago, Ill.
St. Paul Hotel----------St. Paul, Minnesota
Grand Trunk Railway System---Chicago, Ill.
DeWitt Clinton High School-New York City
Richmond Hill High School--New York City
Longfellow High School -----Flint, Michigan
Women's Relief Corps Home--Oxford, N. Y.
Utica State Hospital ----------Utica, N. Y.
New York Central Railroad Co., Harmon,N.Y.
American Thread Co.-----Willimantic, Conn.

UNION BENT TUBE BOILERS are built in both three drum and four drum designs.

The UNION patented integral front water wall is readily adaptable to either type boiler for stoker or powdered coal firing and provides practically twice the usual amount of boiler heating surface exposed to radiant heat. It is an integral part of the boiler unit and has exceptionally free circulation. It does not require condensate or specially prepared feed water.

This design with the addition of the UNION self-contained water cooled bridge wall greatly reduces furnace maintenance and materially increases boiler capacity.

UNION BENT TUBE BOILERS have other distinctive features and are built to the highest standards of design, workmanship and performance.

We are prepared to meet your requirements for all sizes and pressures.

ERIE UNION IRON WORKS PENNA.

Lighting the World at Night

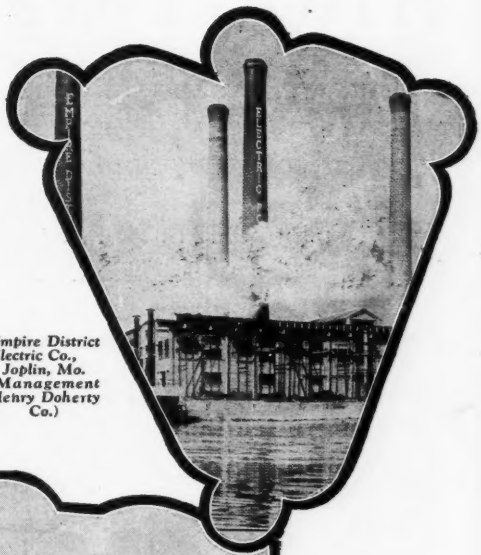
ALL night—and part of the day—your actions are lighted and otherwise governed by a public service power station.

The power must be constant, unceasing, able to handle the peak loads of evening.

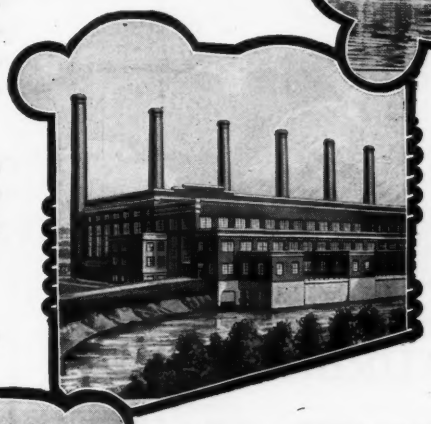
That is why it is interesting to note the number of Connelly Boilers specified by power station executives. When you ask the public service men why they choose Connellys they will tell you because of their economy, because of the dry steam that the Connelly patented steam drying tubes produce, and because of the ability of Connellys to operate easily and continuously at overloads as high as 300% of capacity.

These are Connelly operating features that will guarantee steady power for you and at the same time actually reduce your power costs.

THE D. CONNELLY BOILER CO.
1170 Ivanhoe Road Cleveland, Ohio
53 Years of Knowing How

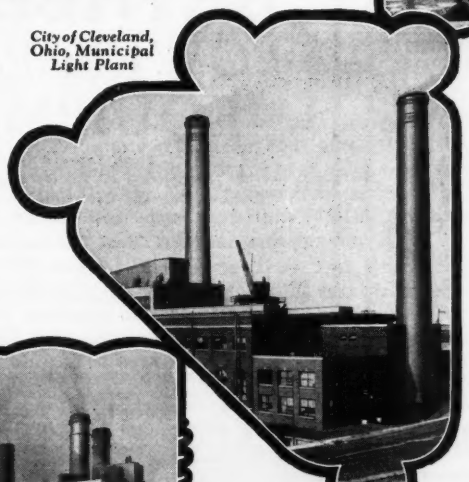


Empire District Electric Co., Joplin, Mo. (Management Henry Doherty Co.)



Metropolitan Power Co., Middletown, Pa. (Management W. S. Barstow Mgt. Assn.)

City of Cleveland, Ohio, Municipal Light Plant



Connelly bent tube boilers are built in capacities from 250 to 4300 H. P. and for steam pressures up to 500 lbs.; Connelly horizontal tube boilers in units from 200 to 3500 H. P. and for steam pressures up to 1400 lbs.

So. California Edison Co., Los Angeles

These are a few of the Public Service Companies and municipal light plants powered by Connellys

	H. P.
Detroit Edison Co., Detroit, Mich.	13000
Henry L. Doherty Co., New York, N. Y.	12458
W. S. Barstow Mgt. Assn., Reading, Pa.	14355
San Joaquin Lt. & Power Co., Buttonwillow, Calif.	4950
N. Y. State Gas & Elec. Co., Ithaca, N. Y.	1000
So. Calif. Edison Co., Los Angeles	16000
So. Illinois Power Co., Collinsville, Ill.	1030
City of Ashtabula, Ohio	1965
City of Bay City, Mich.	840
City of Cleveland, Ohio	11216
City of Fairmont, Minn.	720
City of Frankfort, Ind.	1000
City of Hibbing, Minn.	1200
City of Pasadena, Calif.	2851
City of Philadelphia, Pa.	1000
City of Hannibal, Mo.	500
City of Coldwater, Mich.	600
City of Fremont, Nebr.	500
City of Portland, Ind.	1440

CONNELLY BOILERS

Always Carries the Load

without overheating or laboring. Always are safe to operate. Always are correctly applied.

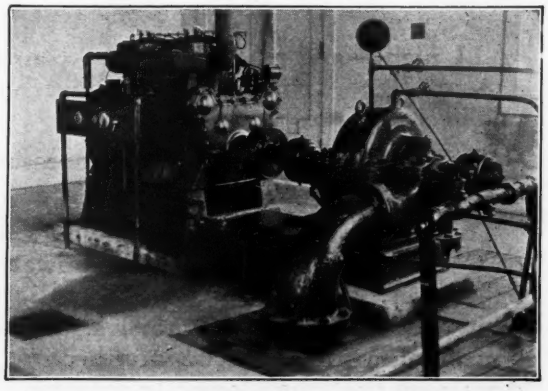
12 to 565 B. H. P.
Gas or Gasoline.

Ample reserve power for emergency

Sterling High Duty

Sterling
THE ENGINE OF REFINEMENT

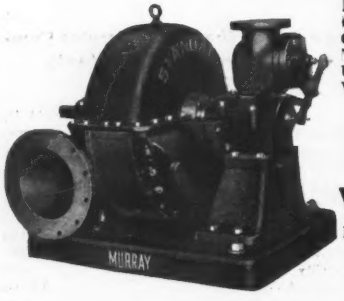
Internal Combustion Engines



Davenport, Fla., has an FC-4 cylinder 85 H. P., Sterling engine direct connected to an American Well Works 4 inch 2-stage type SI centrifugal pump designed for 500 GPM against a total head of 200 feet, running at 1250 r.p.m.

STERLING ENGINE COMPANY, Dept. C-10, Buffalo, N.Y., U.S.A.

TURBINES



BOILERS
CORLISS ENGINES
GENERATOR UNITS
TURBINES
UNI-FLOW ENGINES
WATER WORKS PUMPS

MURRAY IRON WORKS CO.
INCORPORATED 1870
BURLINGTON, IOWA

BETHLEHEM POWER PLANT EQUIPMENT

Heat Transfer Apparatus
Complete Fuel Oil Burning Installations
Reciprocating and Centrifugal Pumps for all Services
Pulverizers

BETHLEHEM STEEL CO., *General Offices,* BETHLEHEM, PA.
District Offices
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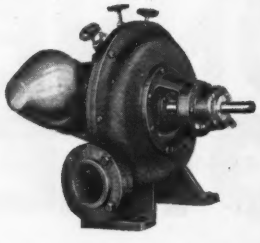
Steam Turbines

1 to 60 H.P.

Coppus Engineering Corporation

340 Park Ave.
Worcester, Mass.



DIESEL ENGINES

Two-Cycle – Airless-Injection

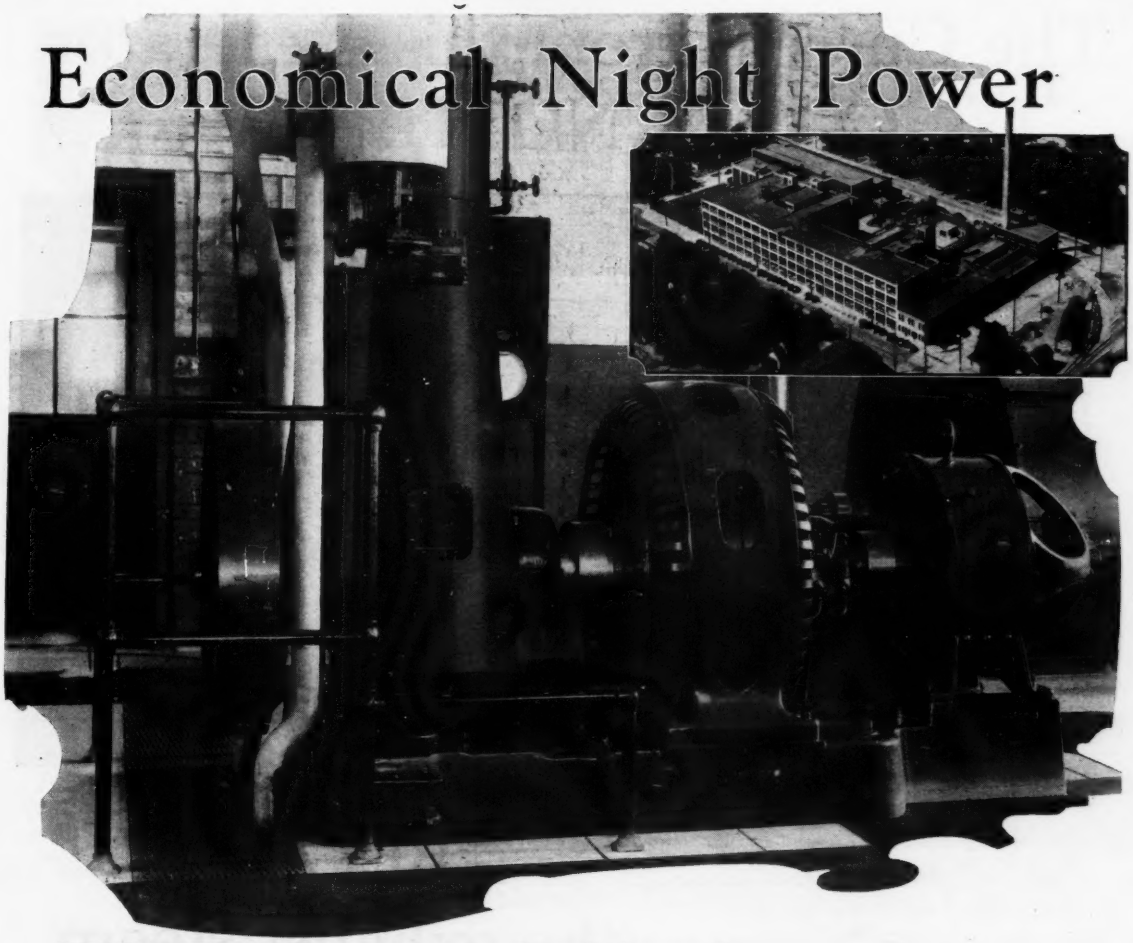
Lowest in over-all operating costs

Write for catalogs, etc.

Fairbanks, Morse & Co.

900 S. Wabash Ave., Chicago A.O.A. 40.32

Economical Night Power



ENGBERG Generating Set Selected by The Piston Ring Company

BECAUSE of its dependable, economical operation, The Piston Ring Company chose the ENGBERG 50 K. W. Alternating Current Generating Set for night and week end service to relieve a 1000 K. W. Uniflow Unit carrying the day load. The steam conditions are 150 to 175 lbs. pressure, 150 degrees superheat, and 1.5 lbs. back pressure.

ENGBERG Generating Sets, both direct and alternating current, are unusually well suited for night service in large plants and for the main load in small plants with all steam conditions. They incorporate rugged, practical design and construction, and operate with practically no maintenance and attention. Because of their good economy in steam and oil, they show a substantial saving over purchased power, as well as the operation of a large unit on partial loads.

WRITE for the Descriptive Catalogs, No. 105, Direct Current; No. 801, Alternating Current.

ENGBERG'S ELECTRIC & MECHANICAL WORKS
833 Vine Street, St. Joseph, Michigan, U. S. A.
Representatives in Principal Cities

Some Recent ENGBERG Installations

American Colortype Company
Artificial Ice & Fuel Company, Waterloo, Ia.
Domestic Laundry, Pendleton, Ia.
Berkey & Gay Furniture Company
Carnation Milk Products Company
Sinclair Oil & Gas Company
Liles Laundry, Columbus, Ohio
Cream of Wheat Company
Cady Lumber Company, Snowflake, Arizona
General Motors Corporation

ENGINES
GENERATING SETS
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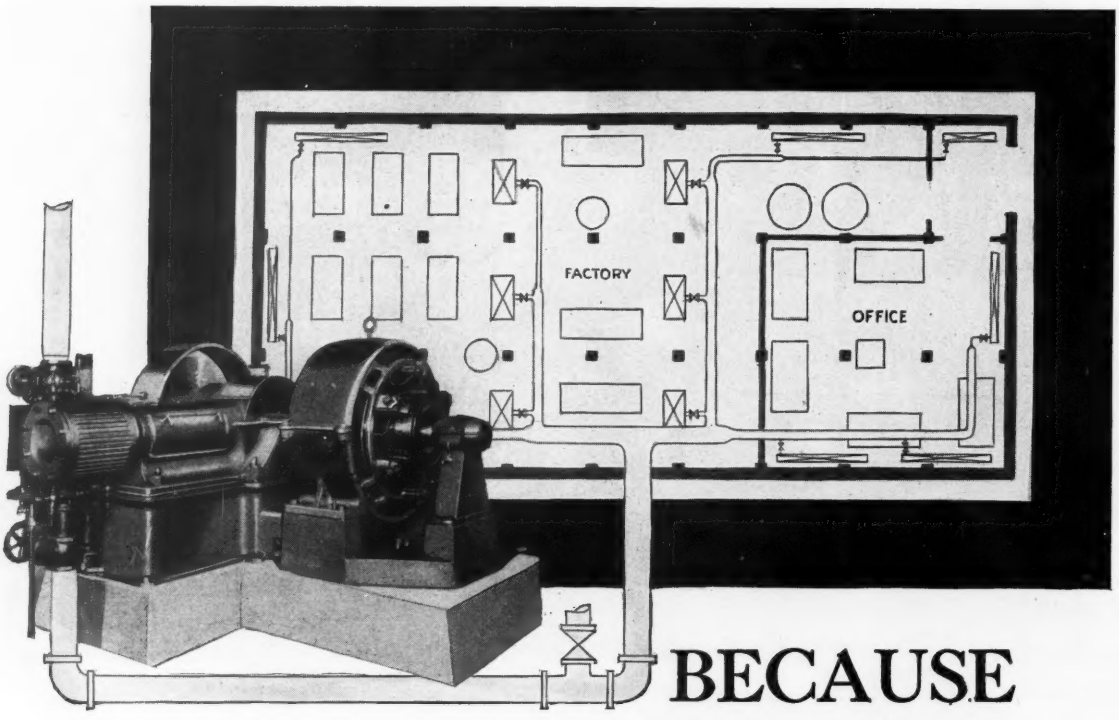
MOTORS
Send for Descriptive Catalogs

ENGBERG
Guaranteed Operation

The Current from this Generator COSTS NOTHING



BECAUSE the exhaust steam from the Troy Engine heats the plant

If you make a steam-engine-driven Machine—

You probably know what it costs you to build a high grade steam engine for your unit. Compare your costs with our delivered prices! We make nothing but engines. We make them economically and well.

Get an estimate.

In the usual engine-generator set-up a Troy Engine proves a reliable, efficient source of power; but when there is a use for low pressure steam, the Troy Engine can usually supply both electric current and heating steam at about the cost of one alone. This holds true where the engine drives a pump, blower or other machine; where low pressure steam is used for plant production processes.

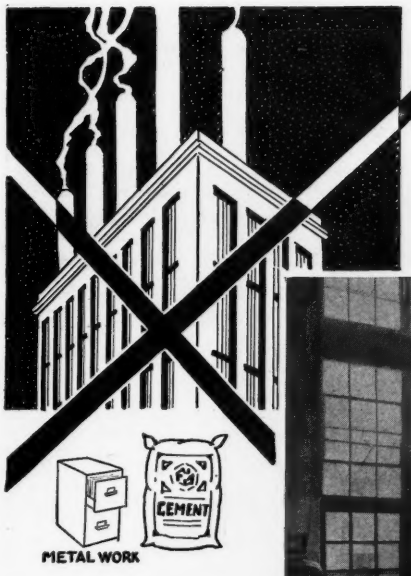
Troy Engines are simple, with very few parts. They are completely protected from dust and other sources of injury. They are automatically lubricated. They operate dependably and economically against back pressure under all plant conditions.

Sizes up to 200 B.hp. in either Vertical or Horizontal Types. Get our prices.

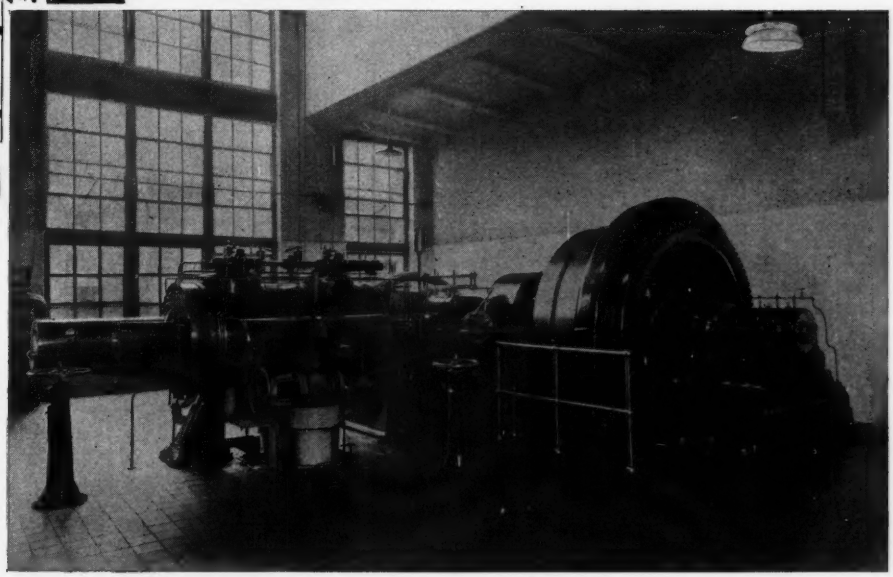
TROY ENGINE & MACHINE CO.
TROY, PA.

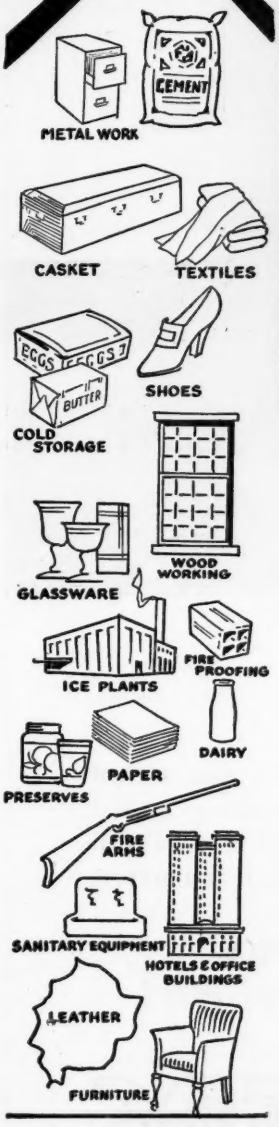
Chicago Office: 118 West Ohio St.
Riley Engineering Co. of Canada, Ltd. 360 Dufferin St., Toronto, Canada

TROY *Self-Oiling* **STEAM ENGINES**



We have done it for others We can do it for You





The Skinner "Guaranteed Saving Contract"

With this contract you are enabled to install your own power plant without tying up a large amount of working capital. It is only necessary to make a part cash payment and let the engine pay the balance in the savings effected against your former power bills.

Every one of these industries has at least one plant that is operating under its own power that is made by "Universal Unaflow" engines installed under the "Guaranteed Saving Contract" plan.

We usually find that the savings to be made in the power-generating department exceed the percentage of profits made by any other department in the plant. We can, upon your request, cite specific installations similar to yours and show the savings made in these plants. We can prove that the "Universal Unaflow" is the most economical steam engine ever built.

Without any obligation on your part, let us show you how much we are able to save you with a "Universal Unaflow."

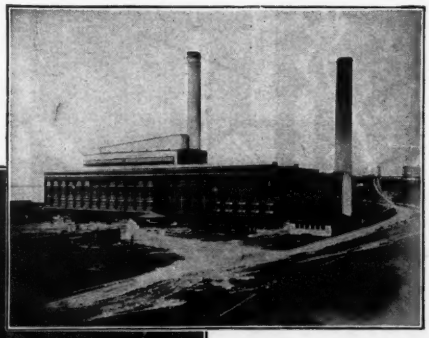
"The Most Economical Steam Engine Built"

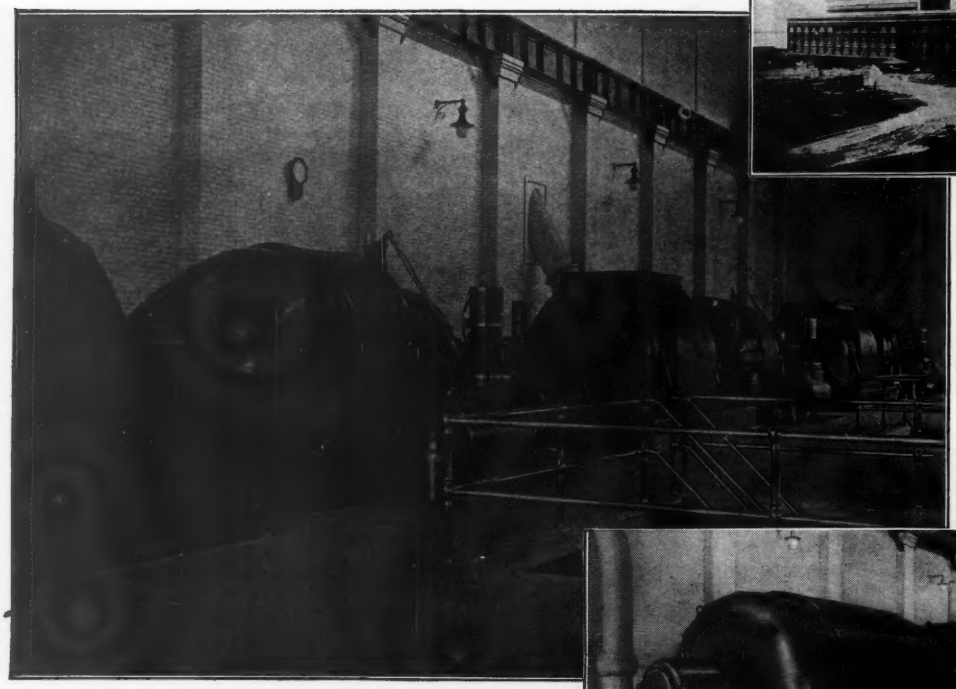
THE "UNIVERSAL UNAFLOW"

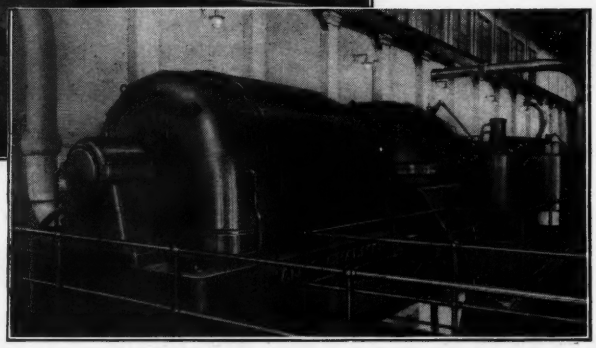
WRITE FOR YOUR COPY

BUILT ONLY BY **SKINNER ENGINE CO., ERIE, PA.**

Branch Offices in all Principal Cities







Steam Turbine Units

50,000 kw. in Allis-Chalmers Steam Turbine and Alternator Units are now installed in the station illustrated above.

In 1914 three 5000 kw. units were installed, in 1919 a 10,000 kw. unit was added, while in 1922 another 10,000 kw. unit was placed in service. In 1925 the 15,000 kw. unit shown above was installed, making a total of six units in the station, ALL OF ALLIS-CHALMERS manufacture.

SUCCESSIVE PURCHASES INDICATE CONFIDENCE BORN OF SATISFACTORY SERVICE

ALLIS-CHALMERS

MILWAUKEE, WIS. U. S. A.

TERRY TURBINE

DURABILITY

The Terry Wheel is made from a single steel forging. The semi-circular buckets or pockets are milled from the solid metal.

The power-producing action of the steam in the wheel takes place entirely on the curved surfaces at the back. As the only function of the blades is to form a series of pockets, close blade clearance is not necessary, and wear of the blade edges has little or no detrimental effect.

Such construction makes for great durability and long life.

The Terry Steam Turbine Company

TERRY SQUARE, HARTFORD, CT.
OFFICES IN PRINCIPAL CITIES
Steam Turbines + Gears + Shaft Couplings

T-1025

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